



# Epsilon EP-I Indexing Drive and FM-2 Indexing Module

## Reference Manual

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Date: December 22, 2006

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**EMERSON**<sup>™</sup>  
Industrial Automation



# Epsilon EP-I Indexing Drives and FM-2 Indexing Module Reference Manual

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- How you tried to solve the problem

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## Document Conventions

Manual conventions have been established to help you learn to use this manual quickly and easily. As much as possible, these conventions correspond to those found in other Microsoft® Windows® compatible software documentation.

Menu names and options are printed in bold type: the **File** menu.

Dialog box names begin with uppercase letters: the Axis Limits dialog box.

Dialog box field names are in quotes: "Field Name."

Button names are in italic: *OK* button.

Source code is printed in Courier font: `Case ERMS`.

In addition, you will find the following typographic conventions throughout this manual.

This	Represents
<b>bold</b>	Characters that you must type exactly as they appear. For example, if you are directed to type <b>a:setup</b> , you should type all the bold characters exactly as they are printed.
<i>italic</i>	Placeholders for information you must provide. For example, if you are directed to type <i>filename</i> , you should type the actual name for a file instead of the word shown in italic type.
ALL CAPITALS	Directory names, file names, key names, and acronyms.
SMALL CAPS	Non-printable ASCII control characters.
KEY1+KEY2 example: (Alt+F)	A plus sign (+) between key names means to press and hold down the first key while you press the second key.
KEY1,KEY2 example: (Alt,F)	A comma (,) between key names means to press and release the keys one after the other.

### Note

For the purpose of this manual and product, "Note" indicates essential information about the product or the respective part of the manual.



### Epsilon Only

For the purpose of this manual and product, the "Epsilon" symbol indicates information about the Epsilon drive specifically.

Throughout this manual, the word "drive" refers to an Epsilon EP-I and the word "base drive" refers to an MDS drive module.

### WARNING

"Warning" indicates a potentially hazardous situation that, if not avoided, could result in death or serious injury.

### CAUTION

"Caution" indicates a potentially hazardous situation that, if not avoided, may result in minor or moderate injury.

### CAUTION

"Caution" used without the safety alert symbol indicates a potentially hazardous situation that, if not avoided, may result in property damage.

# Safety Instructions

## General Warning

Failure to follow safe installation guidelines can cause death or serious injury. The voltages used in the product can cause severe electric shock and/or burns and could be lethal. Extreme care is necessary at all times when working with or adjacent to the product. The installation must comply with all relevant safety legislation in the country of use.

## Qualified Person

For the purpose of this manual and product, a “qualified person” is one who is familiar with the installation, construction and operation of the equipment and the hazards involved. In addition, this individual has the following qualifications:

- Is trained and authorized to energize, de-energize, clear and ground and tag circuits and equipment in accordance with established safety practices.
- Is trained in the proper care and use of protective equipment in accordance with established safety practices.
- Is trained in rendering first aid.

## Reference Materials

The following related reference and installation manuals may be useful with your particular system.

- *All Function Modules Installation Manual* (P/N 400506-03)
- *Epsilon Ei Indexing Drive Installation Manual* (P/N 400501-06)
- *Epsilon EP Drive Installation Manual* (P/N 400518-01)
- *Modular Drive System Reference Manual* (P/N 400525-01)
- *Drives Parameters Reference Manual* (P/N 400504-01)





# Safety Considerations

## Safety Precautions

This product is intended for professional incorporation into a complete system by qualified persons. If you install the product incorrectly, it may present a safety hazard. The product and system may use high voltages and currents, carry a high level of stored electrical energy, or are used to control mechanical equipment that can cause injury.

You must give close attention to the electrical installation and system design to avoid hazards either in normal operation or in the event of equipment malfunction. System design, installation, commissioning and maintenance must be carried out by personnel who have the necessary training and experience. Read and follow this safety information and this instruction manual carefully.

## Qualified Person

For the purpose of this manual and product, a “qualified person” is one who is familiar with the installation, construction and operation of the equipment and the hazards involved. In addition, this individual has the following qualifications:

Is trained and authorized to energize, de-energize, clear and ground and tag circuits and equipment in accordance with established safety practices.

Is trained in the proper care and use of protective equipment in accordance with established safety practices.

Is trained in rendering first aid.

## Enclosure

This product is intended to be mounted in an enclosure that prevents access except by qualified persons and that prevents the ingress of contamination. This product is designed for use in an environment classified as pollution degree 2 in accordance with IEC664-1. This means that only dry, non-conducting contamination is acceptable.

## Setup, Commissioning and Maintenance

It is essential that you give careful consideration to changes to drive settings. Depending on the application, a change could have an impact on safety. You must take appropriate precautions against inadvertent changes or tampering. Restoring default parameters in certain applications may cause unpredictable or hazardous operation.

## Safety of Machinery

Within the European Union all machinery in which this product is used must comply with Directive 89/392/EEC, Safety of Machinery.

The product has been designed and tested to a high standard, and failures are very unlikely. However the level of integrity offered by the product’s control function – for example stop/start, forward/reverse and maximum speed – is not sufficient for use in safety-critical applications without additional independent channels of protection. All applications where malfunction could cause injury or loss of life must be subject to a risk assessment, and further protection provided where needed.

**General warning**

Failure to follow safe installation guidelines can cause death or serious injury. The voltages used in this unit can cause severe electric shock and/or burns, and could be lethal. Extreme care is necessary at all times when working with or adjacent to this equipment. The installation must comply with all relevant safety legislation in the country of use.

**Supply isolation device**

The AC supply or high voltage DC supply must be removed from the drive using an approved isolation device or disconnect before any servicing work is performed, other than adjustments to the settings or parameters specified in the manual. The drive contains capacitors which remain charged to a potentially lethal voltage after the supply has been removed. Allow at least 6 minutes for Epsilon EP206 and 3 minutes for Epsilon EP202/204 after removing the supply before carrying out any work which may involve contact with electrical connections to the drive.

**Products connected by plug and socket**

A special hazard may exist where the drive is incorporated into a product which is connected to the AC supply by a plug and socket. When unplugged, the pins of the plug may be connected to the drive input, which is only separated from the charge stored in the bus capacitor by semiconductor devices. To avoid any possibility of electric shock from the pins, if they are accessible, a means must be provided for automatically disconnecting the plug from the drive (e.g., a latching contactor).

**Grounding (Earthing, equipotential bonding) - High Leakage Current**

The drive must be grounded by a conductor sufficient to carry all possible fault current in the event of a fault. This equipment has high earth leakage current. You must comply with local safety regulations with respect to minimum size and special installation requirements on the protective earth conductor for high leakage current equipment. The ground connections shown in the manual must be followed.

**Fuses**

Fuses or over-current protection must be provided at the input in accordance with the instructions in the manual.

**Isolation of control circuits**

The installer must ensure that the external control circuits are isolated from human contact by at least one layer of insulation rated for use at the applied AC supply voltage. External control circuits identified as PELV circuits do not need this isolation when they are completely within a zone of equipotential bonding, generally within a single enclosure or group of enclosures bonded together.

## Identification of Safety Information

Safety related information through out this manual is identified with the following markings.

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**⚠ WARNING**

“Warning” indicates a potentially hazardous situation that, if not avoided, could result in death or serious injury.

---

**⚠ CAUTION**

“Caution” indicates a potentially hazardous situation that, if not avoided, may result in minor or moderate injury.

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**CAUTION**

“Caution” used without the safety alert symbol indicates a potentially hazardous situation that, if not avoided, may result in property damage.

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**Note**

For the purpose of this manual and product, “Note” indicates essential information about the product or the respective part of the manual.

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Throughout this manual, the word “drive” refers to an Epsilon EP-I and the word “base drive” refers to an MDS drive module.

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## Epsilon Indexing Drives

The Epsilon EP-I drives are stand-alone, fully digital brushless servo drives designed and built to reliably provide high performance and flexibility without sacrificing ease of use.

The use of State-Space algorithms make tuning very simple and forgiving. The drives are designed to operate with up to a 10:1 inertia mismatch right out of the box. Higher (50:1 and more) inertial mismatches are possible with two simple parameter settings.

The Epsilon drives can be quickly configured to many applications in less than 5 minutes with Emerson Control Techniques PowerTools Pro v4.0<sup>1</sup> software on a PC running Windows® 98, NT 4.0, 2000, ME or XP.

Complete diagnostics are provided for quick troubleshooting. A status/diagnostic display on the front of the drive informs the user of the operational or fault status. The last 10 faults are stored in non-volatile memory along with a time stamp for easy recall.

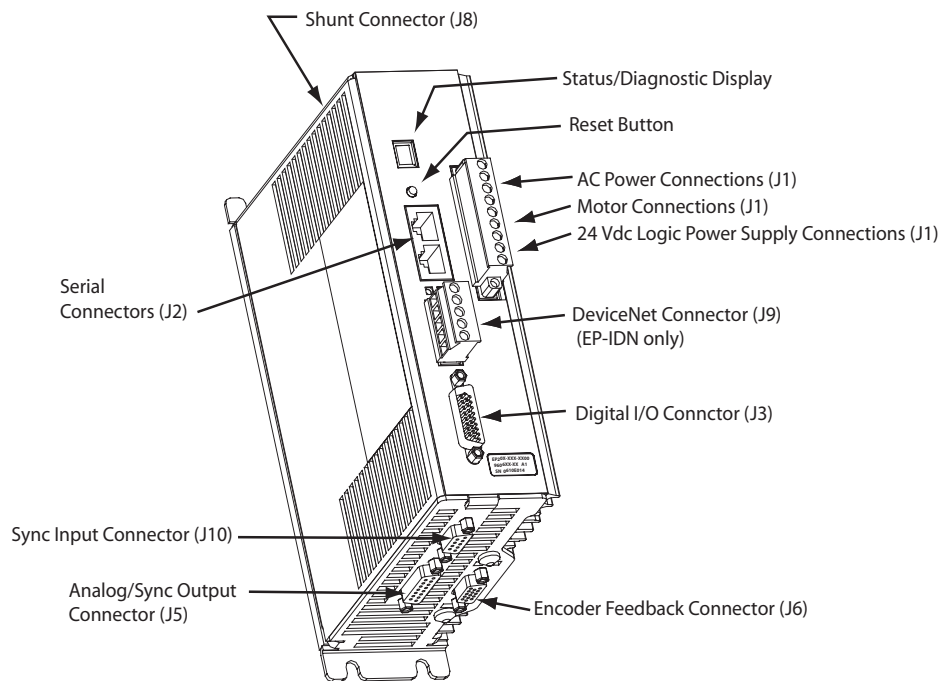


Figure 1: Epsilon EP-IDN Drive Feature Location

Epsilon EP drives are rated at 90 Vac to 264 Vac input voltage. Epsilon EP drives are available in three current ratings.

Drive Model	Continuous Current	Peak Current
EP202-Ixx-EN00	2.2 A RMS	4.4 A RMS
EP204-Ixx-EN00	4 A RMS	8 A RMS
EP206-Ixx-EN00	6.5 A RMS	13 A RMS

The NT and MG motors that are matched to the Epsilon drive provide low inertia, high power to size ratios, and encoder feedback for accurate positioning.

## FM-2 Indexing Module

The FM-2 Module is a compact and rugged indexing module that attaches to the front of the base drive (MDS drive module). It enables the user to initiate up to 16 different indexes, jogging and a single home routine. It also provides eight digital input lines and four digital output lines in addition to the four input and three output lines available on the base drive. The FM-2

1. In this manual Emerson Control Techniques PowerTools Pro v4.0 will be referred to as PowerTools Pro.

Module is setup using PowerTools Pro v4.0 software. PowerTools Pro v4.0 is an easy-to-use Microsoft® Windows® based setup and diagnostics tool.

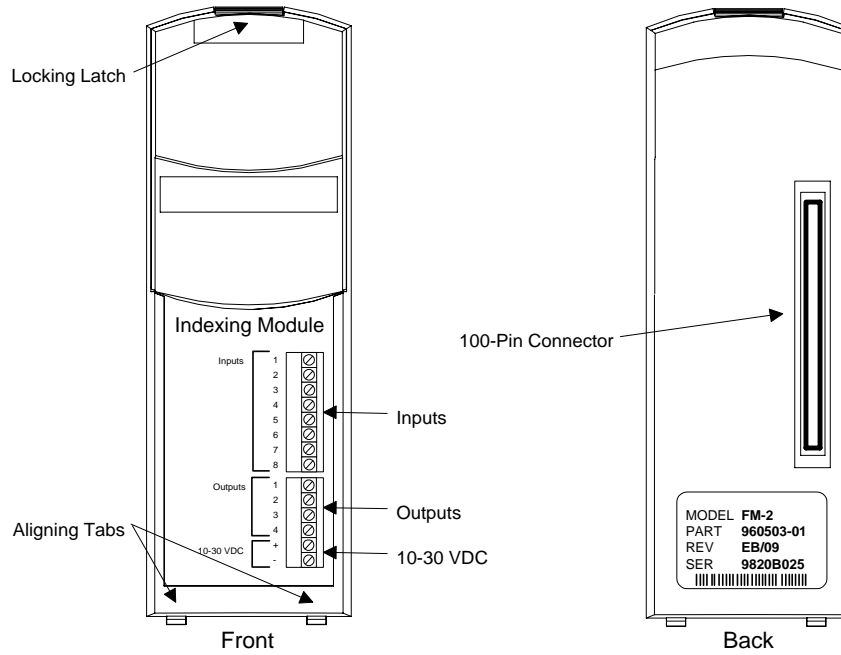


Figure 2: FM-2 Indexing Module Feature Location

# Setting Up Parameters

## Graph View

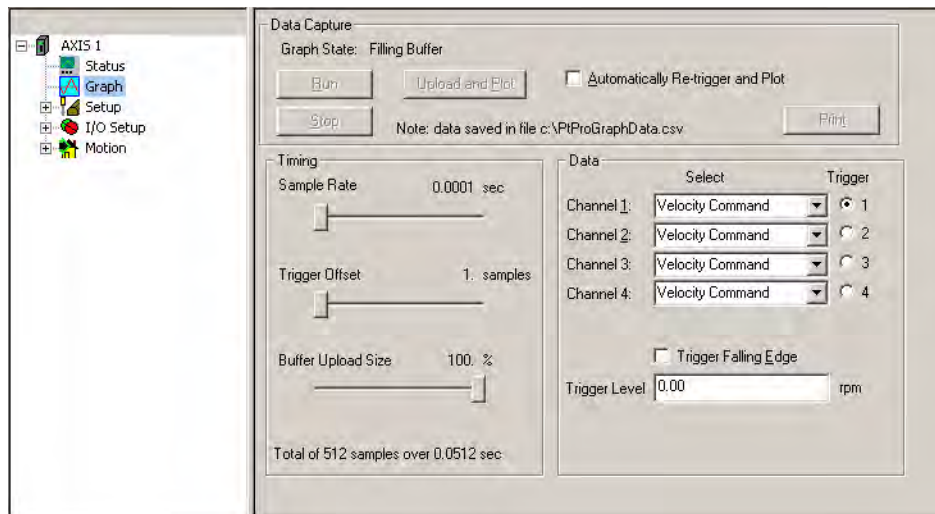


Figure 3: Graph View

## Data Capture Group

### Graph State

There are three graph state conditions in the following order: Filling Buffer, Filled. Waiting for Trigger, and Filled and Triggered.

### Run

The *Run* button commands the drive to begin a high speed data capture of the parameters as selected in each of the four data channels. After the *Run* command button is activated the buffer will fill up to the trigger offset while the words “Filling Buffer” appear indicating this Graph State. Once the trigger offset level is reached the words “Waiting Trigger” will appear next to the Graph State indicating that graphical monitor is now ready to be triggered based on the trigger level selected. The *Run* command button may be activated by the letter “R” on the keyboard.

### Upload and Plot

The *Upload and Plot* button will upload captured data from the drive and display this data in the Graph window. The user should wait for the Graph State to read “Filled and Triggered” before the data is uploaded.

### Stop

The *Stop* button stops the data capture with the data captured at that point. You can upload and plot that data. If the buffer is only partially filled you will get a combination of good and bad data. Stop works well as a manual trigger, in place of the configured trigger.

### Automatically Re-trigger and Plot Check Box

Select the check box and the Automatically Re-trigger and Plot tells PowerTools to monitor the graph state for the triggered condition. When this condition occurs, it automatically initiates the UploadPlot command, waits for a brief time then initiates the Run button to repeat the cycle. Initial the user must press the Run button to start the auto cycle.

This mechanism is only active when the graph view is displayed, If the user enters a different PowerTools view the auto update will stop and it will restart when returning to the Graph view.

### Print

The *Print* button is used to print the graph in the Graph window.

## Timing Group

The sliders can be moved in several different ways.

1. With the mouse pointer over the slider, left click and hold while dragging the slider back or forth to the desired setting.
2. With the mouse pointer over the slider, left click on the slider and then the arrow keys on the PC keyboard can be used to move the slider in fine increments. The Page Up and Page Down keys move the slider in course increments. The Home key will move the slider all the way to the left and the End key will all the way to the right.

### Sample Rate

The Sample Rate slider gives the user control of time spacing for the captured data. To give the user a better idea of what this number means, the total number of samples and total capture time is displayed on the bottom of the “Timing” group box.

### Trigger Offset

The Trigger Offset slider corresponds to the number of samples that will be included on the graph display and data capture prior to the actual trigger. If the Trigger offset slider is completely to the left (min samples), the data capture and graphing will start at the trigger location. If the slider is completely to the right (max samples) the graph will capture data until the trigger point.

### Buffer Upload Size

The buffer upload size slider truncates the drive captured data. If the slider is completely to the right (max) the complete buffer will be uploaded. If the slider is completely to the left, only 1% of the buffer will be uploaded. This parameter does not effect the data capture size, it only defines how much of the buffer will be uploaded.

## Data Group

### Data Channel 1 - 4 Select List Boxes

The Channel 1 through Channel 4 list boxes give the user options for parameter display. If parameters with the same units are mapped on adjacent channels then the graphical display will show these two parameters overlapped on the same x/y axis. If it is desirable to have two adjacent Channels with the same units mapped to separate axis on the graph then the selection (none) should be used on the channel in between these two parameters.

### Trigger Radio Buttons

Selecting the radio button will cause the graphical capture to trigger the capture off the selected Channel. The “Trigger Level” text box on the bottom of the display will change units to the selected channel's parameter units. This trigger level may be changed at any time but the change must be sent to the drive via the Update to RAM or Download button. If a manual trigger is desired, set the channel to None and select the corresponding trigger radio button. If no trigger is selected the capture will begin when the Run button is clicked and end at the end of the Sample Rate.

### Module Parameter

A Module parameter text box is only available once the user has selected Module Parameter from the Select list box. This field is used to define what parameter will be plotted on that channel. The module parameter can be entered two ways: by just typing any module parameter using the program format for the variable, or click the Popup Variables button and the variable window will open. Then select the variable and drag it over to the channel module parameter text box.

### Trigger Mask List Box

This list box is only available when Drive Inputs, Drive Outputs, Module Inputs or Module Outputs is selected in the channel select list box and the Trigger radio button is selected for that channel. The Trigger Mask list box will only list the inputs or outputs for the selected channel parameter.

### Trigger Falling Edge Check Box

When the Trigger Falling Edge check box is selected, the trigger is detected when the data transitions below the trigger level. When the Trigger Falling Edge check box is clear, the trigger is detected when the data transitions above the trigger level.

### Trigger Level

This is the level at which the graph is triggered. The “Trigger Level” text box will change units to the selected channel's parameter unit. This trigger level may be changed at any time but the change must be sent to the drive via the Update to RAM or Download button.



## Setup View

The Setup View contains all of the primary system setup parameters. These parameters must be setup prior to using your system.

By selecting Setup in the Hierarchy Tree, the Setup view will appear on the right side of the view (see Figure 4). The Setup view is divided into four groups for Epsilons and five groups for FM-2 modules. The groups are Identification, Configuration, Drive Encoder Output, Positive Direction, and Switching Frequency with an explanation of each function.

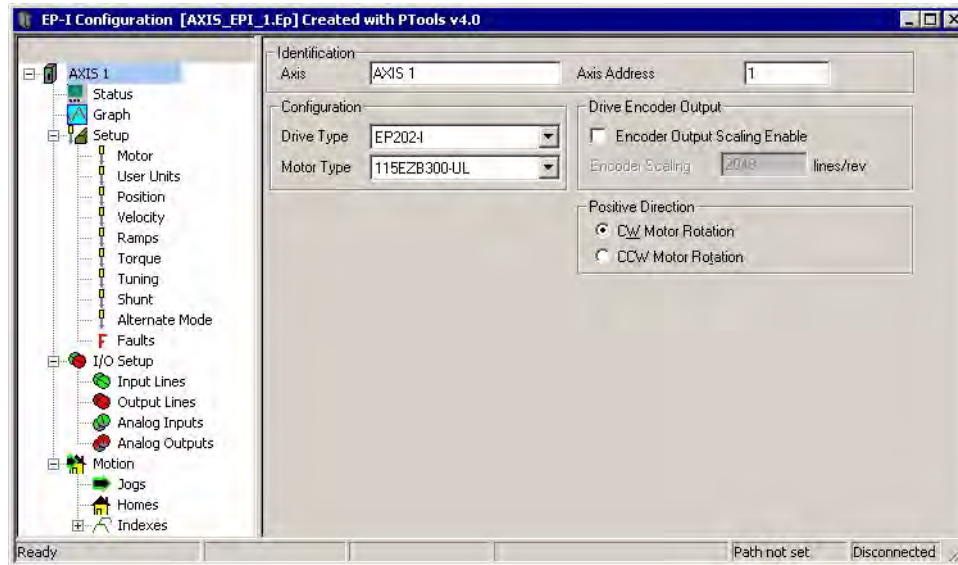


Figure 4: Epsilon EP-I Setup View

### Identification Group

The identification group consists of the Axis and the Axis Address.

#### Axis

Enter a 24 character alpha/numeric name for the device you are currently setting up. Assigning a unique name for each device in your system allows you to quickly identify a device when downloading, editing and troubleshooting. All keyboard characters are valid.

#### Axis Address

Enter the “Axis Address” to which you wish to download the configuration file information. Unless you have changed the Modbus address of your device, leave this parameter set to the default value of 1.

### Configuration Group

#### Drive Type

Select the drive model for the application you are currently setting up.

#### Motor Type

Select the motor type for the application. PowerTools Pro software will display all the motor models that are available and any user defined motors.



Selecting the wrong motor type can cause poor performance and may even damage the motor and/or drive.

---

## Switching Frequency Group (FM-2 only)

### Switching Frequency (FM-2 Only)

“Switching Frequency” is used to select the Drive Module switching frequency. There are two switching frequencies, 5 KHz (default) and 10 KHz. When using 10 KHz the Drive Module current rating will be derated.

## Drive Encoder Output Group

### Encoder Output Scaling Check Box

Select this check box to enable the Encoder Scaling parameter of the Drive Encoder Output.

### Encoder Scaling

This parameter defines the encoder resolution (lines per revolution) of the drive’s encoder output. This feature allows the user to change the drive encoder output resolution in increments of 1 line per revolution up to the density of the encoder in the motor. If the Encoder Output Scaling parameter is set to a value higher than the motor encoder density, the drive encoder output density will equal that of the motor encoder. The default is to the motor encoder density.

## Positive Direction Group

The Positive Direction group consists of a CW (clockwise) Motor Rotation radio button and a CCW (counter-clockwise) Motor Rotation radio button.

Positive motion will move in either a CW direction or CCW direction depending on which direction is selected. Perspective of rotation is defined as you face the motor shaft from the front of the motor.

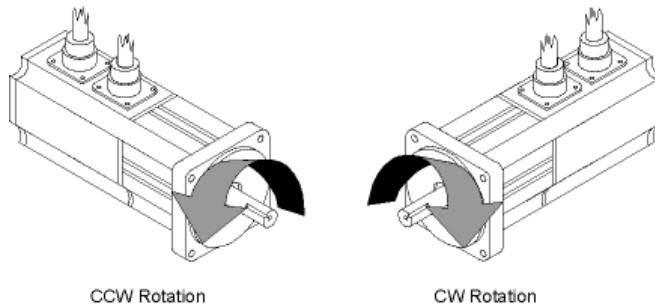


Figure 5: Motor Rotation Perspective

### CW Motor Rotation Option Button

Select this option button for applications in which CW motor rotation is considered to be motion in the positive direction (increasing absolute position).

### CCW Motor Rotation Option Button

Select this option button for applications in which CCW motor rotation is considered to be motion in the positive direction (increasing absolute position).

## Motor View

The Motor view under Setup view is used for many different functions:

1. To see/verify the motor data for a standard motor that had been selected
2. To create a new motor entry in the .ddf file
3. To Run the Auto-Tune feature
4. To store Auto-Tune results into an existing configuration

The primary function of this view is to define the parameters for the given motor that is to be connected to the drive.

Following is a description of all the different functions on the Motor view.

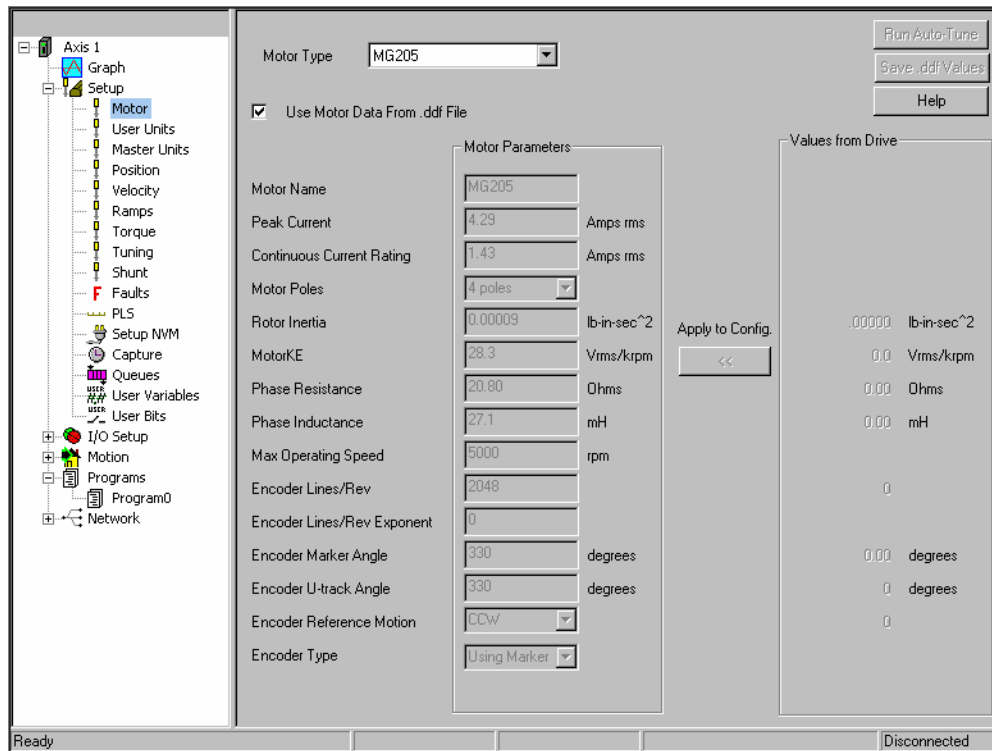


Figure 6: Motor View

## Motor Type List Box

Use this list box to select the motor type. PowerTools Pro software will display all the standard motor models and any user defined motors.



Selecting the wrong motor type can cause instability and may cause property damage to the motor and/or drive.

## Use Motor Data From .ddf File Check box

When selecting a motor for use with the Epsilon drive or a MDS/FM-2 module combination, the user has two basic options:

1. Use a motor that already exists in the standard motor definition file (StdMotor.ddf) or custom motor definition file (Motor.ddf).
2. Create a custom motor that has not been used before.

When selecting option 1 from above (use an existing motor), the user simply selects one of the motors from the Motor Type list at the top of the Motor view. Once the user selects a motor from the Motor Type list, the data for that motor is read from the pertinent .ddf file and then is displayed in the Motor Parameters column on the Motor view (see Figure 6). The parameters in this column will be dimmed and unavailable because the motor information comes directly from the .ddf file.

If the user wishes to edit one or more of the parameters read from the .ddf file, it is necessary to clear the “User Motor Data From .ddf File” check box. Clearing the check box will break the “link” between the motor data displayed on this view, and the motor data in the .ddf file. This is necessary because as soon as the user changes any of the values, it no longer matches the .ddf file, and is now in effect a “custom motor”. When the “User Motor Data From .ddf File” check box is cleared, all of the values in the Motor Parameters column will become available, and the Motor Name will be changed to “New Motor” so that there is no association with the existing motor that was previously selected. The user can now change any of the values as desired and give the motor a new name. Once the values have been changed, the motor data only exists within the active configuration. To save the new values into the .ddf file, the user must click on the Save .ddf Values button on the right side of the view.

## Motor Parameters Column

Motor Parameters column is a column of data displayed on the Motor view under the Setup view (See Figure 6). This column of data contains the values for each of the motor data parameters. The values in this column are unavailable for edit if the “Use Motor Data From .ddf File” check box is selected. This means that since the data is associated with the .ddf file, it cannot be changed. The values in this column become available when the “Use Motor Data From .ddf File” check box is cleared. The user can then change one or more of the parameter values because there no longer is a link to the data in the .ddf file.

If the user does edit motor parameter values on this view, those values are only stored within that particular configuration file. In order to save the values to the .ddf file, the user must click the “Save .ddf Values” button on the right side of the view. Below are the motor parameter with a brief description.

### Motor Name

The motor name is limited to 12 characters and must begin with an alpha character (non-numeric character). This is the motor name that will appear in the “Motor Type” list box above.

### Peak Current

Specifies the peak current allowed by the motor. The motor manufacturer typically provides the peak current data.

If a system is “drive limited” (meaning that the motor can handle more current than the drive can deliver), the peak current actually used by the system may be lower than the value specified here.

### Continuous Current Rating

Specifies the continuous current allowed by the motor. It is used to determine the drive continuous current and peak current limits. The drive can also limit the continuous current to the motor based on the drive capacity. The motor manufacturer typically provides the continuous current data.

If a system is “drive limited” (meaning that the motor can handle more current than the drive can deliver), the continuous current actually used by the system may be lower than the value specified here.

### Motor Poles

Specifies the number of magnetic pole pairs (N-S) on the motor. The supported values are 2, 4, 6, 8, 10, 12, 14 and 16 poles. The motor manufacturer typically provides the motor pole information.

### Rotor Inertia

This parameter specifies the inertia of the motor rotor. The drive uses this parameter to interpret the “Inertia Ratio” parameter. “Inertia Ratio” is specified as a ratio of reflected load inertia to motor inertia.

### Motor KE

Specifies the Ke of the motor. The units are Vrms/ kRPM. The line-to-line voltage will have this RMS value when the motor is rotated at 1000 RPM. The range is 5.0 to 500.0 Vrms/ kRPM. The motor manufacturer will typically provide the Ke data.

### Phase Resistance

Specifies the phase-to-phase resistance of the motor. This value is determined by measuring the resistance between any two motor stator terminals with an ohm meter. The range is .1 to 50 ohms.

### Phase Inductance

Specifies the phase-to-phase inductance of the motor.

### Max Operating Speed

This parameter specifies the maximum speed of the motor when used with a variable speed drive to achieve velocities over the rated base speed of the motor.

### Encoder Lines/Rev

Specifies a coefficient for determining the number of encoder lines per mechanical revolution. The supported values are 1 to 16383. The equation for determining the total number of encoder lines per revolutions is:

$$nLines = n * 10x$$

where:

nLines = Total number of Encoder Lines  
 n = Motor Encoder Lines per Rev Coefficient  
 x = Motor Encoder Exponent

The total number of encoder lines is used both for commutation and for position/velocity control. To properly commutate the motor, the drive must know the electrical angle (the angle between the motor magnetic field and stator coils).

### Encoder Lines/Rev Exponent

Specifies a coefficient for determining the number of encoder lines per mechanical revolution. The supported values are 1 to 16383. The equation for determining the total number of encoder lines per revolutions is:

$$nLines = n * 10^x$$

where:

nLines = Total number of Encoder Lines  
 n = Motor Encoder Lines per Rev Coefficient  
 x = Motor Encoder Exponent

The total number of encoder lines is used both for commutation and for position/velocity control. To properly commutate the motor, the drive must know the electrical angle (the angle between the motor magnetic field and stator coils).

### Encoder Marker Angle

Specifies the electrical angle at which the marker (Z) pulse occurs with reference to  $V_{TS}$  when the motor is spun in the encoder reference direction. At power-up the drive obtains an initial estimate of the electrical angle from the status of the U, V and W commutation tracks. This estimate can be off by as much as 30 °.

When the drive receives the marker pulse, the drive will, within one second, gradually shift the commutation to the more accurate electrical angle specified by this parameter. The system will then operate more efficiently.

### Encoder U-track Angle

Specifies the electrical angle at which the rising edge of the U commutation track will occur with reference to  $V_{TS}$  when the motor is spun in the encoder reference direction.

At power-up the drive looks at the status of the U, V and W commutation tracks and, using this parameter, obtains a crude ( $\pm 30^\circ$ ) estimate of the electrical angle.

### Encoder Reference Motion

Specifies the direction of motion assumed in phase plots of the encoder's quadrature and summation signals. The supported values are CW(1) and CCW(0). Your encoder may have the same phase plot but is generated from a different direction of rotation. This parameter affects the way the drive interprets the quadrature and commutation signals.

### Encoder Type

The supported values for this parameter are 1 and 0. If set to a 1 the drive uses the Encoder Marker angle as well as the Encoder U Angle for commutation. If this parameter is set to a 0, the drive uses only the Encoder U Angle.

## Values from Drive Column

The Values from Drive column is a group of parameters that are constantly being read from the drive. The theory of operation is that the user will often perform an Auto-Tune function that reads/measures/calculates data. The results of those measurements are read from the drive and displayed in the Values from Drive column. Once they are displayed in PowerTools Pro (in the Values From Drive column) the user can apply those values to the Motor Parameters column by clicking on the Apply to Config. button, in the middle of the Motor view (this button looks like a series of arrows pointing from the Values from Drive column towards the Motor Parameters column).

The values in the Values from Drive column are not saved as part of the configuration file. To save these values, the user must use the "Apply to Config" button to save them.

This column is only functional when online with the device. When offline, the values in the Values from Drive column will all read zero.

## Apply to Config. Button

When the user runs the Auto-Tune feature PowerTools Pro reads the results of the Auto-Tune and displays them in the Values from Drive column of the Motor view. After the Auto-Tune, the measured values are only saved in the Drive NVM, and not

in the FM3/4 module. Therefore, in order to store the values in the FM module, the Auto-Tune values must be applied to the configuration file. When the user presses “Apply to Config.,” the values in the “Values From Drive” column are transferred into the Motor Parameters column. Then the values must be downloaded by downloading the entire configuration file using Device > Download.

## Run Auto-Tune Button

The drive has the ability to run an Auto-Tune operation thereby measuring several different motor parameters. Doing so allows the drive to obtain certain parameters that are not typically provided by the motor manufacturer, and also optimizes other drive parameters to work properly with the connected motor/load.

PowerTools Pro allows the user to initiate the Auto-Tune feature from the Motor view.

The following table shows which parameters must be entered in order to run the Auto-Tune feature, and which parameters are measured by the Auto-Tune.

Motor Parameters	Needed to Run Auto-Tune	Measured by Auto-Tune Mode #
Motor Name		
Peak Current	•	
Continuous Current Rating	•	
Motor Poles	•	
Rotor Inertia		3
Motor Ke		3
Phase Resistance		2,3
Phase Inductance		2,3
Max Operation Speed	•	
Encoder Lines/Rev	•	1,2,3
Encoder Lines/Rev Exponent	•	1,2,3
Encoder Marker Angle		1,2,3
Encoder U-Marker		1,2,3
Encoder Reference Motion		1,2,3
Encoder Type		

Some Auto-Tunes cause motion while others do not. It is important to read and understand the warnings and instructions on the Auto-Tune windows. It is strongly recommended to unload the motor if Auto-Tune Mode #3 is commanded.

When online with the drive, to initiate an Auto-Tune, click RunAuto-Tune button. The Auto-Tune dialog box opens and contains warnings and instructions related to the Auto-Tune procedure, as well as selection of the Auto-Tune mode. An example of one of the Auto-Tune windows is shown in Figure 7.

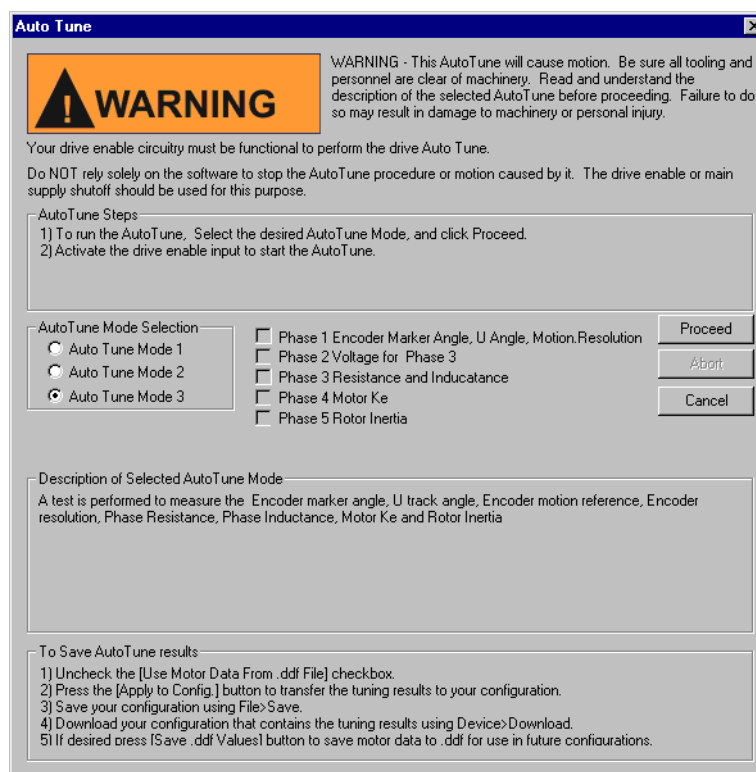


Figure 7: Auto-Tune Dialog Box - Auto-Tune Mode 3

After the Auto-Tune Mode has been selected, click Proceed, to start the Auto-Tune. When the Auto-Tune is completed the results will be in the Values from Drive column on the Motor view.

## Save .ddf Values Button

Once the user has entered the data for the motor they are using, they may or may not wish to save the motor data to the Motor.ddf file so it can be easily recalled at a later time. If the user does not save the motor data to the Motor.ddf file, then the motor data will only reside in the specific application configuration file that it has been entered into.

In order to save the motor data to the Motor.ddf file, click the Save .ddf Values button. This takes all the parameter values and writes them to the Motor.ddf file.

When saving to the .ddf file, if PowerTools Pro finds that a motor already exists with the same name, the User Defined Motor Name Conflict dialog box will appear. The user must then decide how to proceed with saving the motor data .ddf file.

## User Defined Motor Name Conflict Dialog Box

The purpose of this dialog box is to resolve conflicts between the application's motor settings and those defined in the .ddf file.

The User Defined Motor Name Conflict dialog box opens during the following conditions:

1. From the Motor view, click the Save .ddf values button and the motor already exists with the same name but has different motor parameters
2. Opening an application (or uploading a application), where the Use Motor data from the .ddf file check box is select but the data in the application no longer matches the .ddf file.  
This occasionally occurs when a newer version of PowerTools Pro is installed and the parameters for the standard motors has been updated in the .ddf file.

If the motor name does not exist in the .ddf file, it will be written into the file.

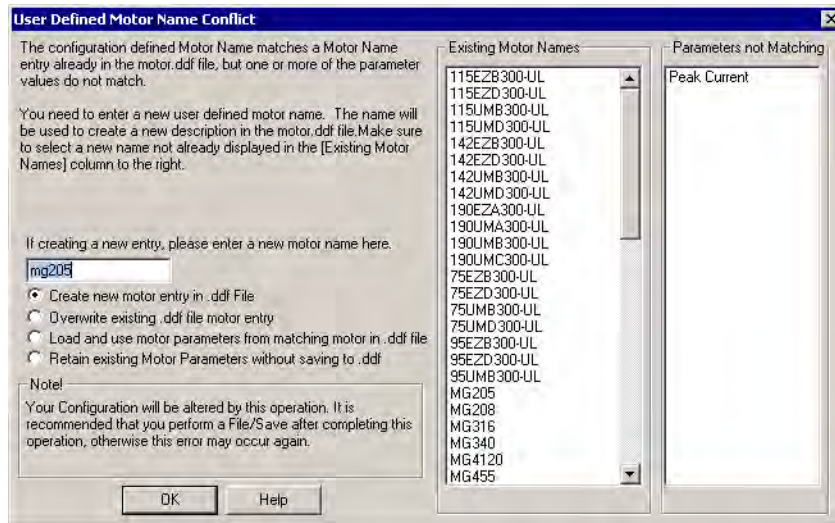


Figure 8: The User Defined Motor Name Conflict Dialog Box

The User Defined Motor Name Conflict dialog box presents the user with four options on how to proceed with saving the motor data. Those four options are:

#### Create new motor entry In .ddf File

The user can select to keep the existing data and create a new entry into the motor.ddf file with a different name. After selecting this option, the user simply enters a new name in the Please enter a new motor name text box. Then click OK, the data will be written to the .ddf file using the new motor name.

#### Overwrite existing .ddf file motor entry

The user can select to overwrite the existing data in the .ddf file with the current data in the Motor Parameters column. If this option is selected, the data in the .ddf file will be overwritten and the overwritten data will be lost forever. The overwritten data cannot be recovered.

If the user attempts to overwrite data for a Standard Motor (in the stdmotor.ddf file), the operation will be canceled and the user will be notified that they cannot proceed. The figure below shows the error message that will be produced when the user attempts to overwrite a standard motor. In this case, the user would need to change the motor name before saving to the .ddf file.



#### Load and use motor parameters from matching motor in .ddf file

If this option is selected, the motor data in the Motor.ddf or stdmotor.ddf file for the matching Motor Name will overwrite the data in the Motor Parameters column. After this option is selected, the “Use Motor Data From .ddf File” check box will be selected, and all the parameter values will be unavailable.

#### Retain existing Motor Parameters without saving to .ddf

If the user selects this option, the values in the Motor Parameters column will not be written to the motor.ddf file, and the values will only reside within the configuration file. The specific motor data values will not be available for selection in the Motor Type list box because they are not saved to the .ddf file. The “Save .ddf Values” operation is in effect canceled.

### Existing Motor Names List Box

This list box is part of the User Defined Motor Name Conflict dialog box and contains all the names of the motors that exist in the motor.ddf and stdmotor.ddf files. When selecting a new name, it is important to select a name that is not already displayed in this list box.



## Parameters Not Matching List

This list is part of the User Defined Motor Name Conflict dialog box and displays the parameter value(s) from the Motor Parameters column that do not match the equivalent parameter value in either the motor.ddf or stdmotor.ddf files, for the motor with the matching name.

This helps the user to determine whether they wish to overwrite, cancel, or create a new motor with this Save .ddf Values operation.

## User Units View

The User Units View is used to scale the desired application units into known values. All information for distance, velocity, and accel/decel units are set up here and used throughout the system setup.

By selecting User Units in the Hierarchy Tree, the User Units View will appear on the right (see Figure 9).

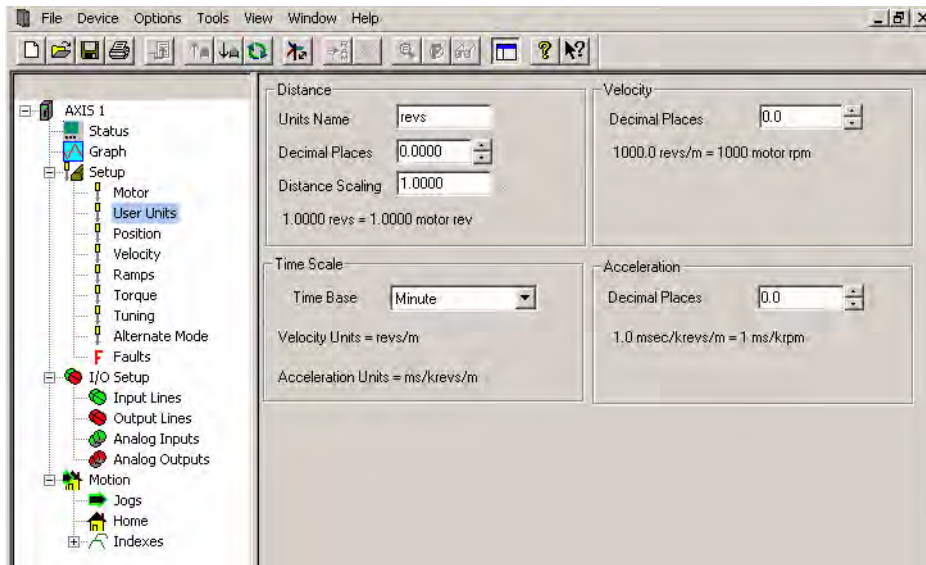


Figure 9: User Units View

## Distance Group

### Units Name

Select the type of units to be used throughout the configuration for all Position/Distance parameters. The default units are revs.

### Decimal Places

This will specify the number of digits after the decimal place to be used in all distance/position parameters for the entire configuration.

### Distance Scaling

This will specify the number of user units in 1.0000 motor revolution. This parameter also determines the resolution of distance/position parameters for the entire configuration. The number of decimal places specified here sets the maximum resolution.

For Example: If the user has a leadscrew with a 0.5" lead and wishes to perform indexes of 0.025", the Units Scaling must be set to 0.500. By specifying three digits after the decimal place, the user will be able to enter the three digits necessary for the index distance.

## Velocity Group

### Decimal Places

This will specify the number of digits after the decimal place to be used in all Velocity parameters.

## Time Scale Group

### Time Base

Select either minute or second as the time scale for the configuration. The default time scale is minutes. If the selected time scale is seconds, then the velocity units will appear as user units/sec. If the selected time scale is minutes, the velocity units will appear as user units/minute.

If the selected time scale is seconds, then the accel/decel units will appear as user units/sec<sup>2</sup>. If the selected time scale is minutes, the accel/decel units will appear as msec/(1000 (user units)/min) or msec/(k (user units)/min). Therefore, for accel/decel units, the default is msec/kRPM (the same as previous versions of the FM-2 module).

## Acceleration Group

### Decimal Places

This will specify the number of digits after the decimal place to be used in all Acceleration/Deceleration parameters.

## Position View

The Position View allows you to set up and view the parameters related to drive positioning. In, Position has been selected in the Hierarchy Tree. The right side of the view is divided into groups. An explanation of the groups and their functions is provided below.

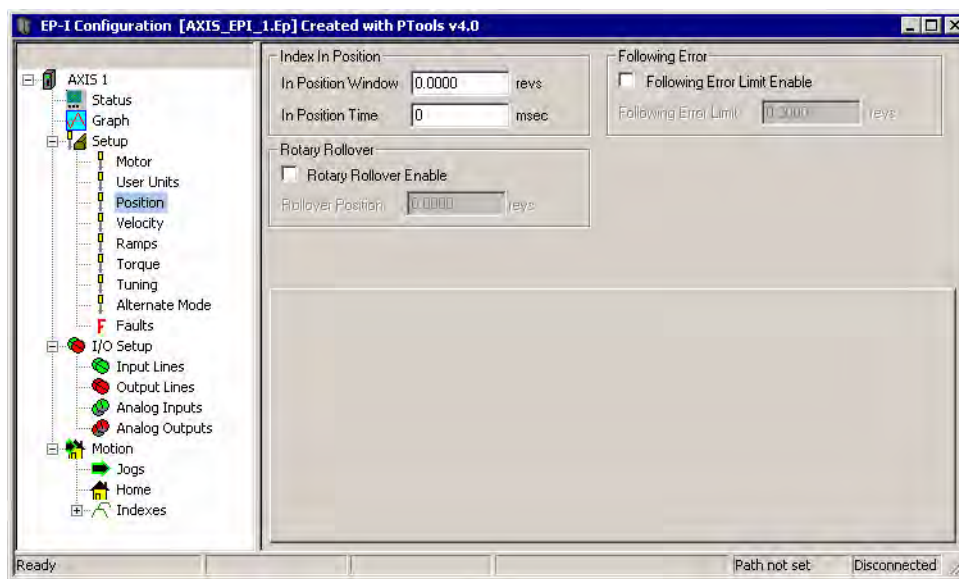


Figure 10: Position View

## Index In Position Group

### In Position

The In Position (InPosn) source will activate at the end of a move if the absolute value of following error is less than or equal to the In Position Window for the In Position Time.

### In Position Window

The absolute value of the Following Error must be less than or equal to this value at the end of an index in order for the InPosn source to activate. This window is set in units specified in the User Units View.

For example:

The In Position window is set to 0.0025 revs. At the end of an index, the following error is calculated to be 0.0012 revolutions. Therefore, the InPosn output will activate.

Or the In Position window is set to 0.001 inches. If at the end of an index, the following error is calculated to be 0.0015 inches, then the InPosn output will not activate.

### In Position Time

This is the amount of time in seconds that commanded motion must be complete and the absolute value of the following error must be less than the In Position Window parameter for the InPosn output to activate. If set to zero (default), then the InPosn output will activate as soon as motion stops and the following error is less than the In Position Window parameter.

## Following Error Group

### Following Error Limit Enable Check Box

Select this check box to enable (or clear this check box to disable) the Following Error Limit. If enabled, a fault will be generated if the absolute value of the following error ever exceeds the value in the following error parameter. If disabled, a fault will never be generated.

### Following Error Limit

Following Error is the difference between the Position Command and the Position Feedback. It is positive when the Position Command is greater than the Position Feedback. If the absolute value of the following error exceeds the value entered here, the drive will generate a Following Error Fault (F). All accumulated Following Error will be cleared when the drive is disabled.

The Following Error Limit is defined in user units.

## Rotary Group

### Rotary Rollover Enable Check Box

Select this check box to enable (or disable if check box is clear) the rotary rollover feature.

### Rollover Position

This parameter is used in rotary applications and determines the position at which the internal position counter will be reset to zero.

#### Example:

The user has a rotary table application with distance user units of degrees, 360.00 degrees/1 rev. The Rotary Rollover would be set to a value of 360°.

The motor is traveling in the positive direction. As the feedback position reaches 359.999 and continues on, the feedback position will reset (or roll-over) to zero. If the motor changes direction and travels in the negative direction, the position will rollover at 0 to 359.999 degrees and count down. The resolution of the rotary rollover point is determined by the Distance Units Decimal Places parameter on the User Units view in the PowerTools Pro software.

If an absolute index is used with a non-zero rotary rollover point, the FM-3/4 module will calculate the shortest path to its destination and move in the required direction.

To force the motor to run a certain direction, use the Rotary Plus or Rotary Minus type of indexes.

## Online Tab

While online with the device, the lower half of the view is the Online tab and the following real-time data will be displayed.

## Motor Position Group

### Position Command

This is the commanded position in user units generated by the device. This is set to zero when the Absolute Position Valid output function is activated. The Position Command is specified in user units.

### Position Feedback

This is the feedback position of the motor. It is set to zero when the Absolute Position Valid output function is activated. Position Feedback is specified in user units.

### **Following Error**

The Following Error is the difference (in user units) between the Position Command and the Position Feedback. It is positive when the Position Command is greater than the Position Feedback.

### **Encoder Position**

The motor position in encoder counts since power up when the value was set to zero. This is a signed 32 bit value. This is set to zero when the Absolute Position Valid output function is activated.

### **Pulse Input Posn**

This parameter returns the total number of actual pulses received on the pulse input hardware. This value is active in all operating modes.

## Velocity View

This view allows the user to set the drive limits, and if online, view the velocity feedback parameters.

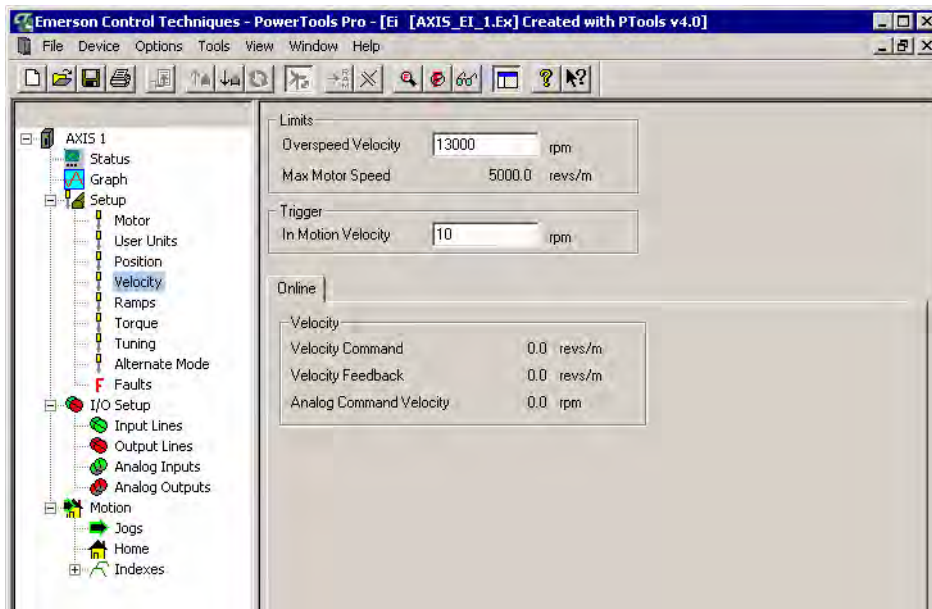


Figure 11: Velocity View - Online

### Limits Group

#### Overspeed Velocity

This parameter specifies the maximum allowable speed. If the Velocity Feedback exceeds either the drive's internal overspeed fault limit or the value of the Overspeed Velocity, an Overspeed Fault will be generated. The internal overspeed fault limit is equal to 150 percent of the Motor Maximum Operating Speed.

### Trigger Group

#### In Motion Velocity

This parameter sets the activation point for both the In + Motion and In - Motion output functions. The output function will deactivate when the motor velocity slows to half of this value.

### Online Tab

### Velocity Group

All parameters in this group are only available when online with the device.

#### Velocity Command

The Velocity Command is the actual command received by the velocity loop.

#### Velocity Feedback

This parameter is the actual feedback motor velocity.

#### Analog Command Velocity

The drive is in Analog Velocity mode this parameter gives the current velocity commanded due to the Analog input function.

## Ramps View

### Ramps Group

#### Stop Deceleration

The value you enter here defines the rate of velocity change to zero speed when a Stop input function is activated.

#### Travel Limit Deceleration

The value you enter here defines the rate of velocity change to zero speed when a Travel Limit input function is activated.

### Limits Group

#### Analog Accel/Decel Limit

This feature allows you to limit the accel and decel rate when using the analog input for velocity control. This makes it very simple to use the drive in high performance, variable speed, start-stop applications such as Clutch-Brake replacements without requiring a sophisticated controller to control the acceleration ramps. In applications which do not require the drive to limit the ramps such as when using an external position controller, the parameter can be set to “0” (its default value). If the Analog Accel/Decel Limit parameter value is changed during a ramp, the new ramp limit is imposed within the next servo loop update.

## Torque View

This view allows the user to edit the Torque Limit and when online with the device view the torque parameters.

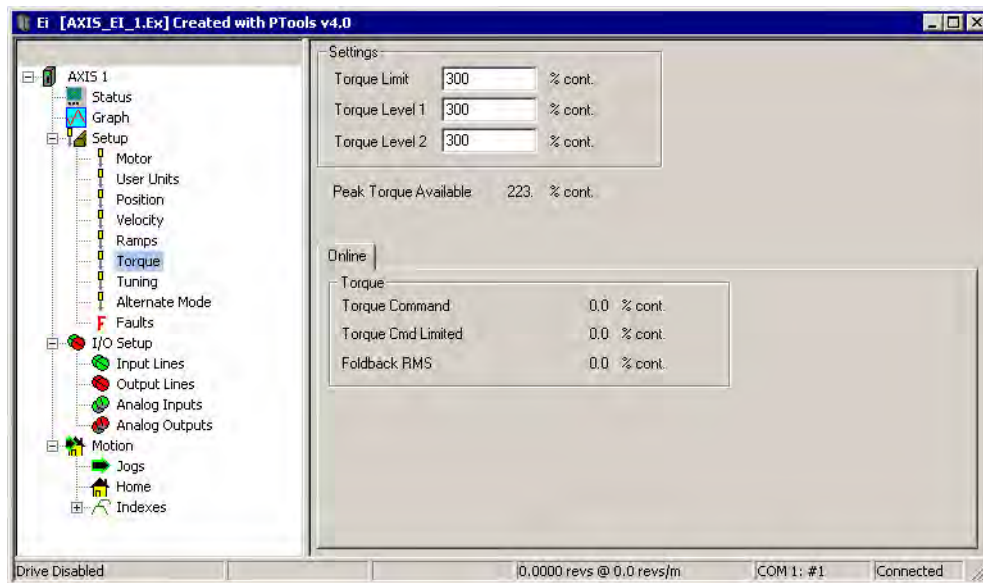


Figure 12: Torque View - Online

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### Note

The Torque Limit value takes effect only when the Torque Limit Enable input function is active.

---

These parameters are continuously updated while online with the drive.

### Settings Group

#### Torque Limit

This value is the level which the Torque Command will be limited to when the Torque Limit Enable input function is active. To make the Torque Limit always active, set the Torque Limit Enable Input function to be Always Active.

---

## Torque Level 1 and 2

This parameter sets the activation level for the Torque Level 1 Active and Torque Level 2 Active output functions.

## Peak Torque Available

This displays the maximum torque available from the selected drive and motor combination. This is calculated by PowerTools Pro and is not a drive parameter.

## Online Tab

### Torque Group

#### Torque Command

The torque available from the particular drive and motor combination.

This parameter returns the torque command value before it is limited. The torque command may be limited by either the Torque Limit (if the Torque Limit Enable input function is active) or Current Foldback.

#### Torque Cmd Limited

This displays the percent of torque being commanded to the motor. This value is the result of the Torque Command after being limited by the current foldback and the Torque Limit value (if active).

#### Foldback RMS

This parameter accurately models the thermal heating and cooling of the drive and motor. When it reaches 100 percent, current foldback will be activated.

## Tuning View

All parameters on the Tuning view are related to the load on the motor and application requirements.

The load on the motor is specified by two parameters: Inertia Ratio and Friction. Typical application requirements are specified by the response adjustment and Feedforward Gains. Position Error Integral is provided to compensate for systems with high friction or vertical loads. Low Pass Filter is provided to filter machine resonance that are present in some applications.

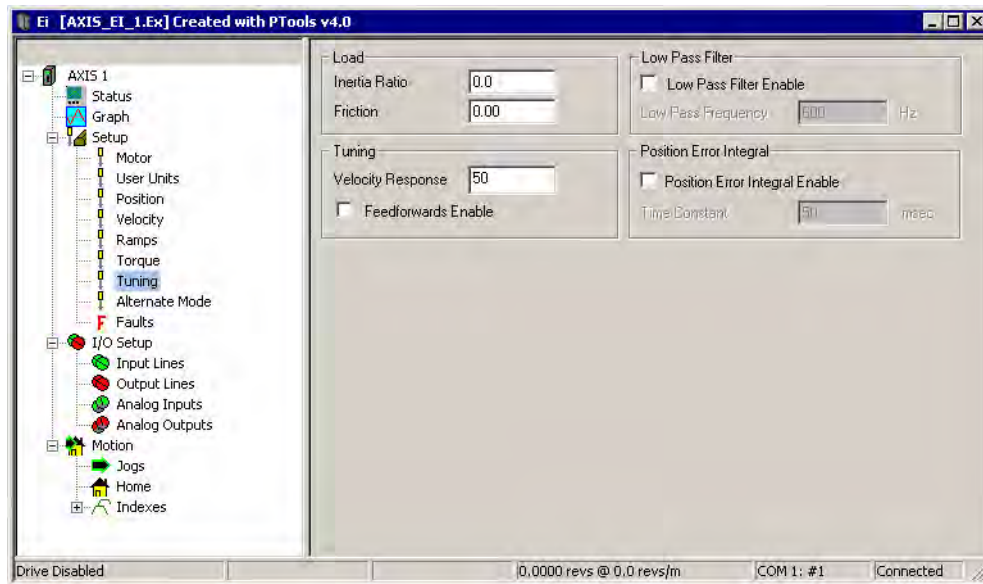


Figure 13: Tuning View

## Load Group

### Inertia Ratio

Inertia Ratio specifies the load to motor inertia ratio and has a range of 0.0 to 50.0. If the exact inertia is unknown, a conservative approximate value should be used. If you enter an inertia value higher than the actual inertia, the resultant motor response will tend to be more oscillatory.

### Friction

This parameter is characterized in terms of the rate of friction increase per 100 motor RPM. If estimated, always use a conservative (less than or equal to actual) estimate. If the friction is completely unknown, a value of zero should be used. A typical value used here is less than one percent.

## Tuning Group

### Velocity Response

The Velocity Response parameter adjusts the velocity loop bandwidth with a range of 1 to 500 Hertz. In general, it affects how quickly the drive will respond to commands, load disturbances and velocity corrections. A good value to start with (the default) is 50 Hz. The maximum value recommended is 80 Hz.

### Feedforwards Enable Check Box

When this check box is selected feedforwards are enabled, the accuracy of the Inertia and Friction parameters is very important. If the Inertia parameter is larger than the actual inertia, the result could be a significant overshoot during ramping. If the Inertia parameter is smaller than the actual inertia, following error during ramping will be reduced but not eliminated. If the Friction parameter is greater than the actual friction, it may result in velocity error or instability. If the Friction parameter is less than the actual friction, velocity error will be reduced but not eliminated.



## Low Pass Filter Group

### Low Pass Filter Enable Check Box

This check box when selected enables a low pass filter applied to the output of the velocity command before the torque compensator. The low pass filter is only active in Pulse and Velocity modes, not Torque Modes.

### Low Pass Frequency

This parameter defines the low pass filter cut-off frequency. Signals exceeding this frequency will be filtered at a rate of 40 dB per decade.

## Position Error Integral Group

### Position Error Integral Enable Check Box

When selected this enables the Time Constant parameter.

### Time Constant

Position Error Integral is a control term which can be used to compensate for the continuous torque required to hold a vertical load against gravity. It is also useful in low speed applications which have high friction.

It also helps maintain accurate command execution during steady state or low frequency torque disturbances (typically less than 10 Hz) or when holding a non-counterbalanced vertical load in position.

The adjustment parameter is Position Error Integral Time Constant which is available in the Tuning View of PowerTools Pro. This parameter determines how quickly the drive will attempt to eliminate the following error. The time constant is in milliseconds and defines how long it will take to decrease the following error by 63%. (3 time constants will reduce the following error by 96%). The range for this parameter is 5 to 500 milliseconds. In certain circumstances the value actually used by the drive will be greater than the value specified in PowerTools Pro because the minimum allowed time constant value is a function of the 'Response' parameter. The formula is  $\text{Min. Time Constant} = 1000/\text{Response}$ .

For example, with 'Response' set to 50, the minimum time constant value is  $1000/50 = 20$  msec. A higher time constant value will minimize instability with more compliant loads such as long drive shafts, or spring loads. A lower time constant setting will increase the response and will stiffen the system.

## Alternate Mode View

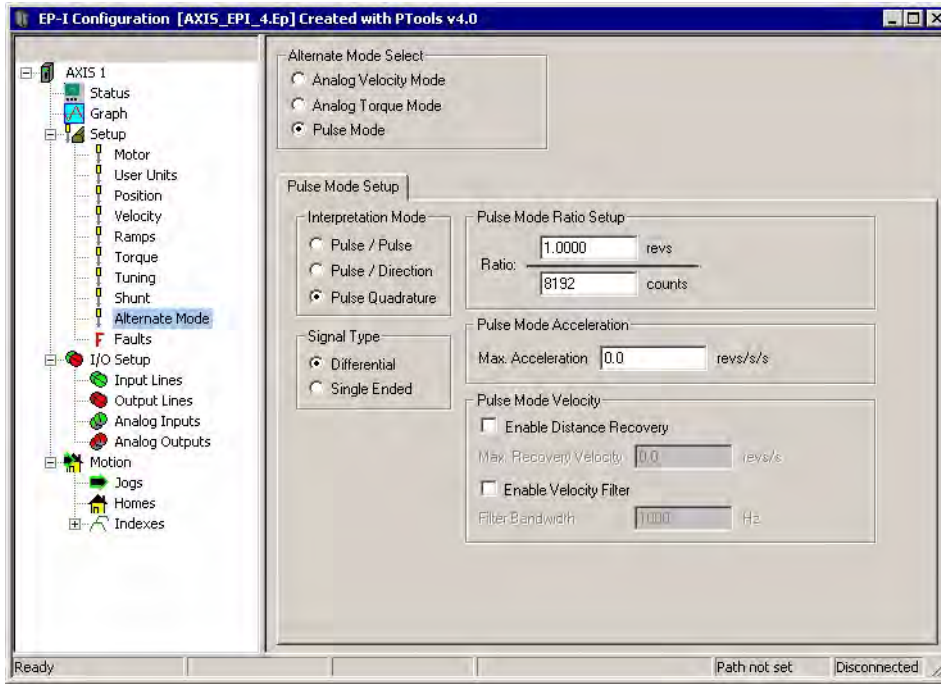


Figure 14: Alternate View

## Alternate Mode Selection

See “Alternate Mode Select” on page 70 for details on selecting a mode of operation.

## Faults View

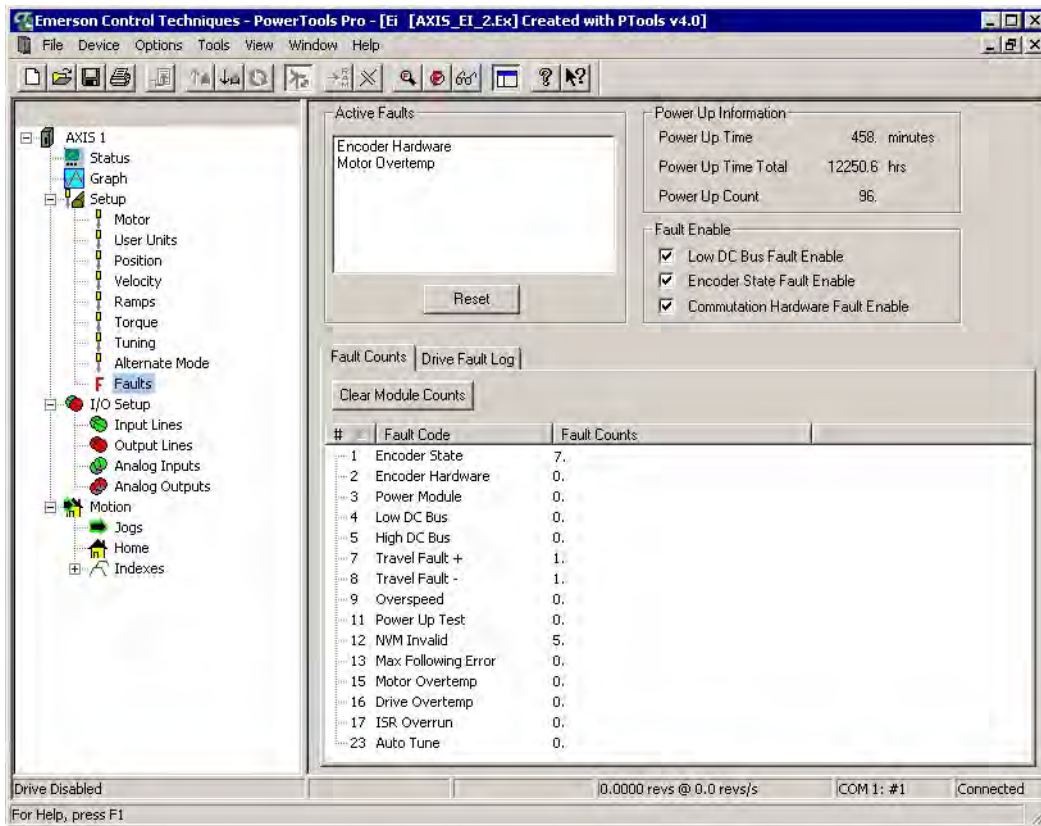


Figure 15: Faults View - Online

## Fault Enable Group

### Low DC Bus Fault Enable

This parameter's default setting is enabled. When enabled, the drive will detect a low DC bus at 60 Vdc and will log a Low DC Bus Fault if a power down is not completed after the low DC bus is detected. Clearing this check box will disable the Low DC Bus Voltage Fault. This will allow the drive to operate at a DC bus voltage below 60 Vdc as long as the logic power is supplied by the Alternate Power Supply (APS) with an Epsilon classic drive and a Logic Power Supply with the Epsilon EP-I drive.

### Encoder State Fault Enable

This parameter's default setting is enabled. When enabled, the drive will detect encoder state faults. Refer to Fault Codes in the Diagnostic and Troubleshooting section of this manual. The drive will not detect Encoder State faults when the fault is disabled. Disabling encoder faults is necessary for some types of programmable encoders when the state transitions are not always deterministic.

### Commutation Hardware Fault Enable

When this checkbox is selected, faults occurring from the commutation tracks U, V, and W will be recognized as "E" faults in the drive. When this checkbox is clear, no fault will occur due to the commutation tracks. This functionality can be useful to diagnose the nature of the "E" fault. If the checkbox is clear and "E" faults are still occurring, then the encoder lines (A, A/, B, B/, Z, Z/) are the most likely source of the "E" fault.

# I/O Setup

## Input Lines View

The Input Lines view is used to assign an input function to an input line. This view is divided into two windows. The “Input Function” window, on the left side, displays the input functions available and the function configuration. The “Input Line” window, on the right side, displays the input lines, attached input functions and the debounce value.

To assign an input function, position the mouse pointer over the function on the left to assign it to the line on the right. Press the left mouse button while over the function, and hold the button down. While holding the left button down, drag the function until the pointer is positioned over the desired line and release the left mouse button.

To unassign an input function, position the pointer over the function on the left. Press the left mouse button while over the function, and hold the button down. While holding the left button down, drag the function over to the right and release the left mouse button.

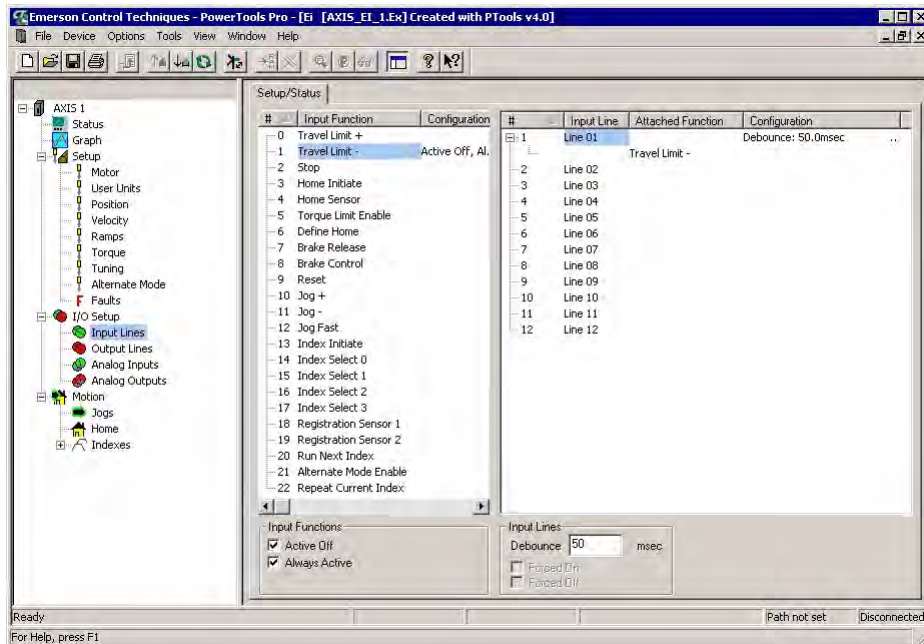


Figure 16: Inputs View

## Input Function Window

This window allows the user to select an input function and assign it to an input line. When online with the device there will be a virtual LED to the left of the input function name that shows the state of the input function.

### Configuration

The configuration of each input function is displayed next to the input function when the active state is changed from default. The default configuration is Active On.

### Active Off Check Box

This check box allows you to change the “Active On/Off” state. Select the desired input function in the input function window, then select or clear the “Active Off” check box.

Making an input function “Active On” means that it will be active when 10 Vdc to 30 Vdc is applied to the input line it’s assigned to and is inactive when no voltage is applied to the line. Making an input function “Active Off” means that it will be active when no voltage is applied to the input line and inactive while 10 Vdc to 30 Vdc is being applied.

### Always Active Check Box

This check box is used to make an input function “Always Active”. When you make an input function always active, it’s active whether assigned to an input line or not. If you make an input function “Always Active” then assign it to an input line, that function will be active whether or not voltage is applied to the assigned line.

## Input Line Window

This window displays the input function assigned to the input line and the configuration of the input line and input function.

### Attached Function

This displays the Input Function assigned each particular Input Line.

### Configuration

The debounce value is displayed next to each input line, the active state for the attached input function is shown next to the input function.

## Debounce Text box

The debounce value is displayed next to each input line. This feature helps prevent false input triggering in noisy electrical environments. Enter a “Debounce Time” in milliseconds. The value entered here is the minimum amount of time the input line will need to be active before it is recognized as a valid input.

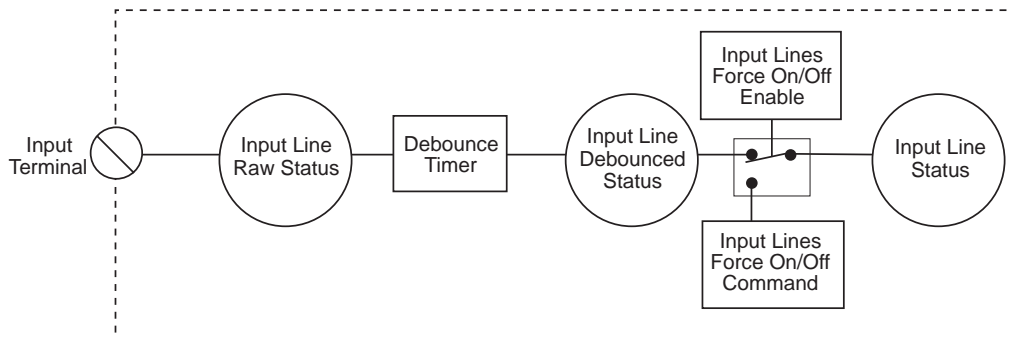


Figure 17: Input Line Diagram

## Outputs View

This view is divided into two windows. The “Output Function” window, on the left side, displays the available output functions. The “Output Line” window, on the right side, displays the output lines, the attached output function and the line configuration (Active Off).

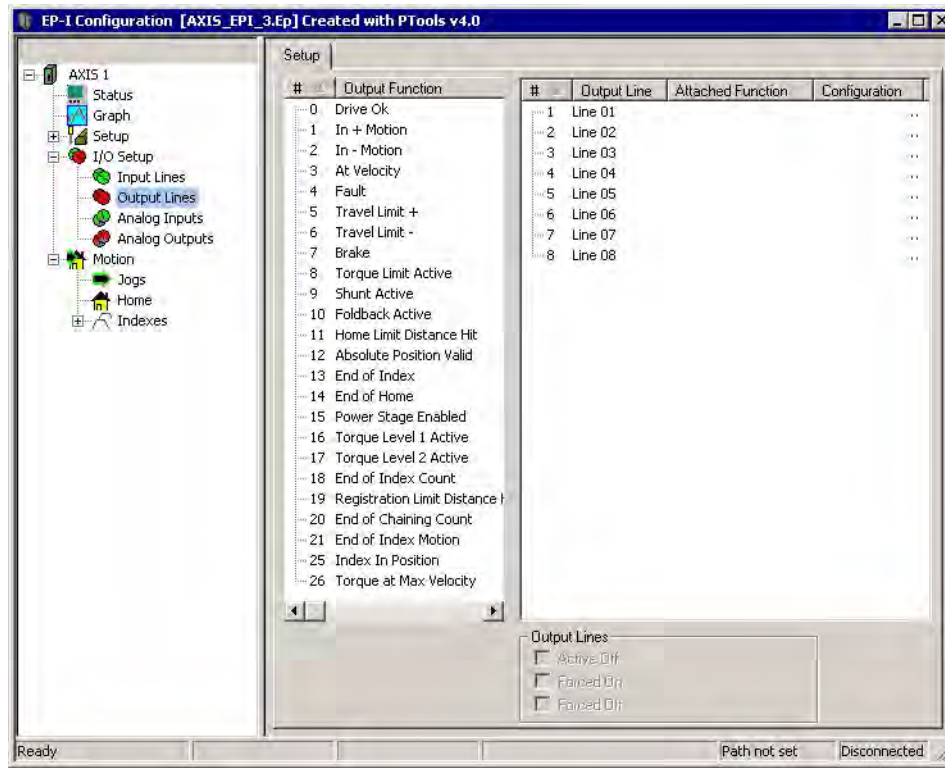


Figure 18: Outputs View for a Epsilon EP-I Drive

### Note

For wiring information, refer to the “Installation” section of the *Epsilon EP Installation Manual* (P/N 400518-01), or the *Modular Drive System Reference Manual* (P/N 400525-01).

## Output Function Window

This window allows selection of the output function to be assigned to an output line.

To assign an output function, position the mouse pointer over the function on the left to assign it to the line on the right. Press the left mouse button while over the function, and hold the button down. While holding the left button down, drag the function until the pointer is positioned over the desired line and release the left mouse button.

To unassign an output function, position the pointer over the function on the left. Press the left mouse button while over the function, and hold the button down. While holding the left button down, drag the function over to the right and release the left mouse button.

## Output Lines Window

### Attached Function

This feature displays the Output Function assigned to each particular Output Line.

### Configuration

The configuration of each output line is displayed next to the output line when the active state is changed from default. The default configuration is Active On, see Active Off check box below.

## Active Off Check Box

The default active state of an output line is Active On. This means that the output line will supply a voltage when the result of the logical Or of the output function(s) assigned to that output line is active.

Making an output line "Active Off" means that the line will be "Off" (not conducting) when the result of the logical Or of the output function(s) assigned to that output line is active, and will supply a voltage when the logical Or of the output function(s) is not active.

## Analog Inputs View

The drive has one analog input channel that accepts a +10 V to -10 V signal. The drive has a 12-bit over sampled to 14-bit analog to digital converter (A/D), which is used to transform the analog voltage to a usable parameter. The analog input is scanned by the drive every 100 microseconds and the module at the trajectory update rate.

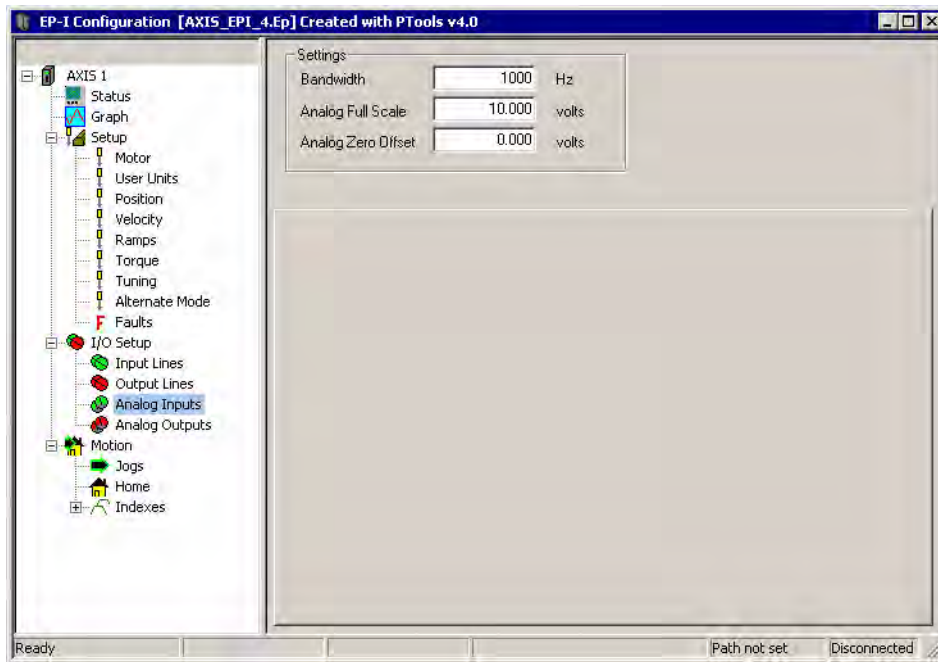


Figure 19: Analog Inputs View

### Bandwidth

This parameter sets the low-pass filter cutoff frequency applied to the analog input. Signals exceeding this frequency will be filtered at a rate of 20 db per decade.

### Analog Full Scale

This voltage sets the maximum value that the analog input will reach in normal operation. Valid range for this parameter is +10 volts to -10 volts.

### Analog Zero Offset

This parameter is used to null any voltage present at the drive when a zero analog velocity command is provided. The amount of offset can be measured by the Analog Input parameter when a zero analog velocity command is supplied.

Default = 0 Volts

### Online Tab

#### Analog Input Status

This is a display of the real time status of the analog input in volts. It is only available when you are online with a device.

## Analog Outputs View

This view displays the setup and feedback data for the two Analog Outputs.

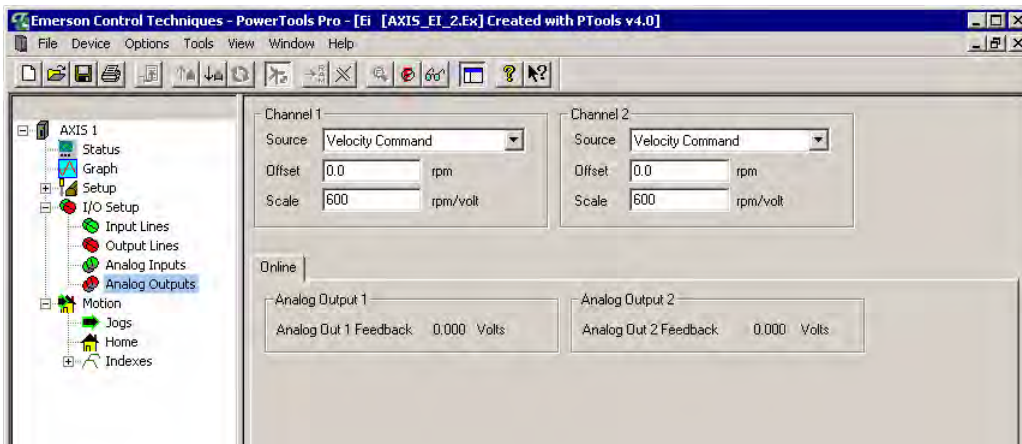


Figure 20: Analog View - Online

## Analog Outputs Group

### Source

Select the signal to use as the source for the Analog Output. There are six options: Velocity Feedback, Velocity Command, Torque Feedback, Torque Command, Position Feedback and Following Error. The scaling and offset are affected by the source parameter selected. The units of the scaling and offset are adjusted according to the source parameter.

### Offset

Each analog output channel includes a programmable Analog Output Offset. This feature allows you to “zoom in” to a desired range effectively increasing the resolution. The units of this parameter is dependent upon the Analog Output Source selection.

### Scale

Each analog output channel includes a programmable Analog Output Scale. This feature allows you to “zoom in” to a desired range effectively increasing the resolution. The units of this parameter is dependent upon the Analog Output Source selection.

### Online Tab

#### Analog Out Feedback

This is a display of the real time status of the two analog outputs in volts. It is only available when you are online with a device.

## Jog View

This view allows you to enable and define jog velocity, acceleration and deceleration.



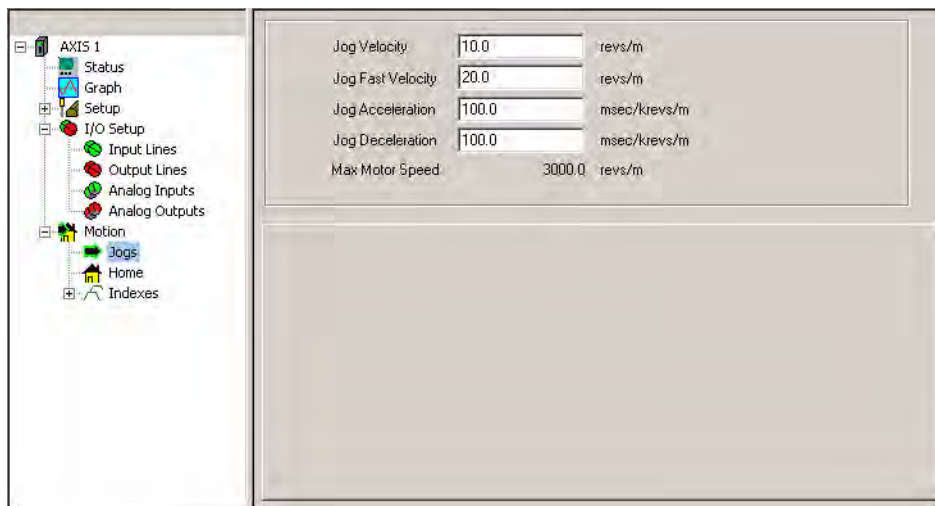


Figure 21: Jog View

### Jog Velocity

This parameter specifies the velocity used for jogging with the Jog + or Jog - input functions.

### Jog Fast Velocity

This parameter specifies the velocity used for fast jogging with the Jog Fast input function in conjunction with either the Jog + or Jog - input functions.

### Acceleration

This parameter specifies the acceleration value to be used during the jog. The acceleration units are defined by the Time Scale parameter on the User Units view.

### Deceleration

This parameter specifies the deceleration value to be used during the jog. The deceleration units are defined by the Time Scale parameter on the User Units view.

### Max Motor Speed

This parameter specifies the maximum motor speed for the motor type selected on the Setup view.

## Home View

This view allows you to enable and define the home function.

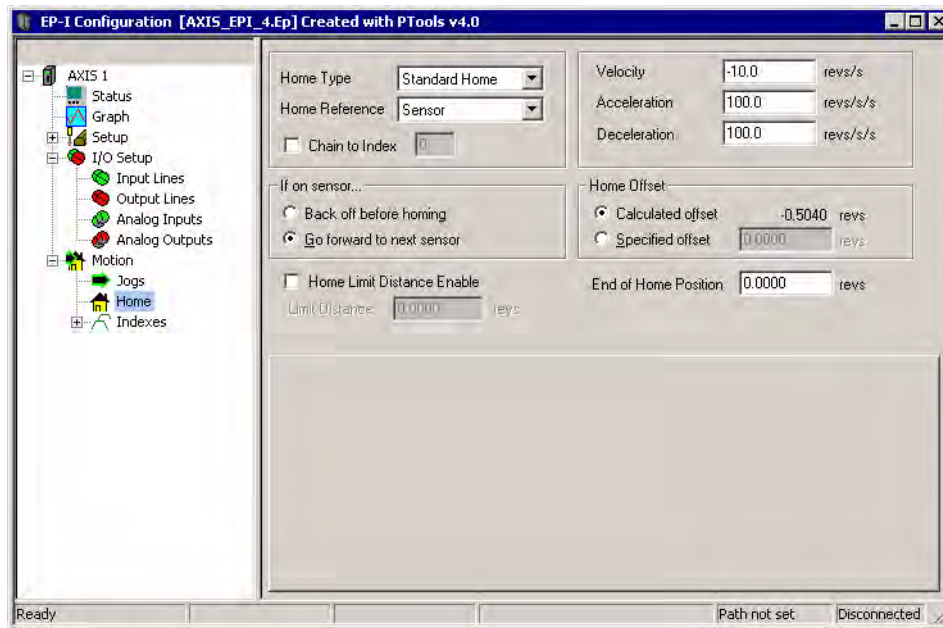


Figure 22: Home View

### Home Type

The Home Type parameter determines the type of home, Standard Home or One Side Home.

### Home Reference

The Home Reference parameter determines how the reference position is calculated. When Standard Home Type is selected the parameter can have one of three different values: 'Sensor', 'Marker', or 'Sensor and Marker'. When One Side Home Type is selected the parameter value is 'Sensor'.

#### Sensor

When the Home Reference is 'Sensor' the active going edge of the 'Home Sensor' input function is used to establish the reference position.

#### Marker

When the Home Reference is 'Marker' the rising edge of the motor encoder's marker channel is used to establish the reference position.

#### Sensor and Marker

When the Home Reference is 'Sensor and Marker' the reference position is established using the first marker rising edge after the Home Sensor input function goes active.

### Chain to Index

When the check box is selected, the device will then start the index shown in the text box after the home cycle is complete.

### Velocity

This parameter specifies the velocity used for homing. Use a positive value to make the drive home in the positive direction and a negative value to make the drive home in the negative direction. The velocity units are defined by the Time Scale parameter on the User Units view.

## Acceleration

This parameter specifies the acceleration value to be used during the home. The acceleration units are defined by the Time Scale parameter on the User Units view.

## Deceleration

This parameter specifies the deceleration value to be used during the home. The deceleration units are defined by the Time Scale parameter on the User Units view.

## If on sensor ... Group

### Back off before homing Option Button

The Back off before homing flag effects the drive's behavior when the home sensor is active at the time the home is initiated. If the flag is set, the drive will back off the sensor. It does this by moving the opposite direction to that specified by the sign of the home velocity. It continues moving in this direction until the sensor deactivates. It then decelerates to a stop and performs a standard home.

### Go forward to next sensor Option Button

The Go forward to next sensor flag effects the drive's behavior when the home sensor is active at the time the home is initiated. If the flag is set, the drive will go forward to the next sensor. It does this by performing a standard home routine looking for the rising edge of the home sensor.

## Home Offset Group

### Calculated Offset Option Button

The calculated offset is defined as the distance travelled during deceleration ramp from the home velocity to a stop plus the distance travelled at the home velocity for 400 $\mu$ s. This extra distance is used to guarantee that the motor will not need to backup after the deceleration ramp.

### Specified Offset Option Button

The specified offset allows the user to choose an exact offset from the Home Reference.

### Home Limit Distance Enable Check Box

The "Home Limit Distance Enable" check box enables the Home Limit Distance parameter. If this flag is not set, there is no limit to the distance the drive will travel during a home routine.

### Limit Distance

This parameter places an upper limit on the distance the motor will travel during the home. In situations where the reference position indicator (sensor or marker) is not seen, this parameter limits the total distance the motor will move.

## End of Home Position

The "End of Home Position" designates the absolute position of the home in the machine coordinate system. At the completion of the home cycle, the End of Home Position value is put into the command and feedback positions. At the completion of the home cycle, the Absolute Position will have the value entered for this parameter. This value is in motor revolutions.

## Index # View

This view allows the user to define or assign the various indexes.

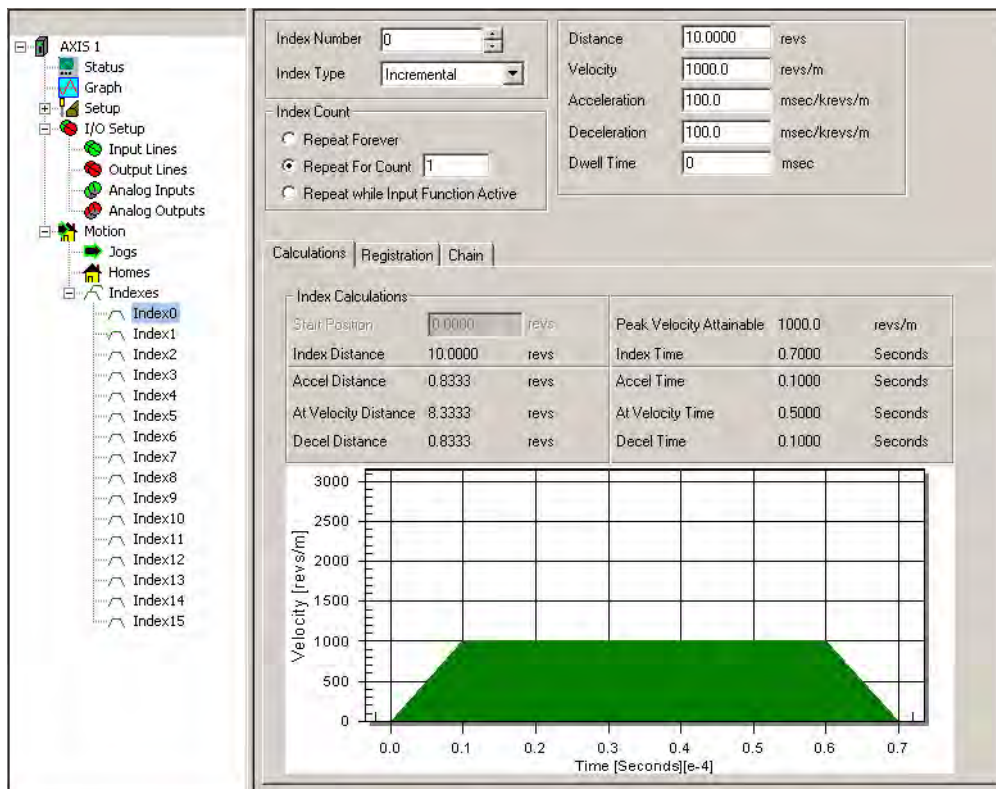


Figure 23: Index0 View

## Index Number

The device supports up to 16 indexes (0 - 15). Use the scroll arrows to change the index number or click on the index number in the hierarchy tree.

## Index Type

### Absolute

Absolute indexes are used in applications where the motor must travel to a specific position, regardless of where the motor is when the index is initiated.

### Incremental

An incremental index will move the motor a specified distance in the + or - direction regardless of the starting position. The direction of the incremental index motion is determined by the sign (+ or -) of the Index Distance parameter.

### Registration

A Registration Index runs at the specified velocity until a registration sensor or torque level is seen or until it reaches the Registration Limit Distance. If a Registration Sensor is seen, then the index runs an additional specified Registration Offset distance. If Registration Indexes are compounded, then Index ends either Limit Dist or End of Registration offset. It will then start the next index at the ending velocity.

### Rotary Plus and Rotary Minus

Rotary Plus and Rotary Minus type indexes are typically used in applications which use rotary rollover. If Rotary Rollover is enabled on the User Units View, a Rotary Plus index will always move in the positive direction and a Rotary Minus index will always move in the negative direction. These indexes are forced to run in a specific direction regardless of the starting point. If Rotary Rollover is not enabled, these indexes will function like Absolute indexes.

## Distance/Position/Limit Distance

This parameter changes from Distance to Position depending on whether you have chosen Absolute, Incremental or Registration as the Index Type. The maximum distance/position/limit distance value supported is +/- 214,748.3648 user units.

## Velocity

The Velocity parameter specifies the velocity used for the index. The velocity parameter is unsigned and must be greater than zero.

## Acceleration

The Acceleration parameter specifies the acceleration value to be used during the index. The acceleration is specified in units of ms/(k(user unit)/min) or user units/sec<sup>2</sup>, depending on the time base parameter from the User Units View.

## Deceleration

The Deceleration parameter specifies the deceleration value to be used during the index. The deceleration is specified in units of ms/(k(user unit)/min) or user units/sec<sup>2</sup>, depending on the time base parameter from the User Units View.

## Dwell Time

Time in ms between indexes. The dwell starts at the end of the commanded motion of the index, and the output line End of Index is turned on at the end of the dwell time. Default is 0 ms. Upper limit is 65,535 seconds.

## Index Count Group

This parameter specifies how many times in a row this index is to run before proceeding on to the next index.

### Repeat Forever

If repeat forever is chosen, the index will repeat continuously until a stop command is received.

### Repeat For Count

If repeat for count is chosen, the user must specify how many times the index is to repeat. The maximum index count is 65,535.

### Repeat while Input Function Active

If repeat while input function active is chosen, the index will repeat continuously when the Repeat Current Index input is active.

## Registration Tab

The registration index parameters are set on this tab. The signal for the registration mark can come from one of four sources: Registration Sensor 1, Registration Sensor 2, Torque Level 1, or Torque Level 2.

The Offset can either be Calculated by PowerTools Pro or Specified by the user in user units. If Calculated Offset is selected, the motor will stop at the specified deceleration ramp. If Specified Offset is selected, the motor will come to a stop the specified offset distance away from the registration mark. If the Specified offset is less than the Calculated offset, the motor will stop at the programmed deceleration ramp and then back up to the specified distance from the registration mark. The Specified offset is a signed parameter; if the index direction is negative, the specified offset parameter should also be negative.

## Calculations Tab

This displays various index calculations, such as index distance, index time, acceleration, deceleration and at velocity results.

### Start Position

When an “Absolute Index” is selected, the “Start Position” of the index can be set to provide index calculations from a non-zero position. The “Start Position” is defaulted to zero. The “Start Position” parameter is not available using an “Incremental Index”.

## Chain Tab

Multiple indexes can be chained together so that they run sequentially. As each index is configured, this tab allows for no chaining or end of the chain (stop), continue to the next index (start next index), or wait for a Run Next Index Input signal and continue to next index (wait for run...). Which index is to be run next is specified in the Index Chain text box. The default chain setting is Stop.

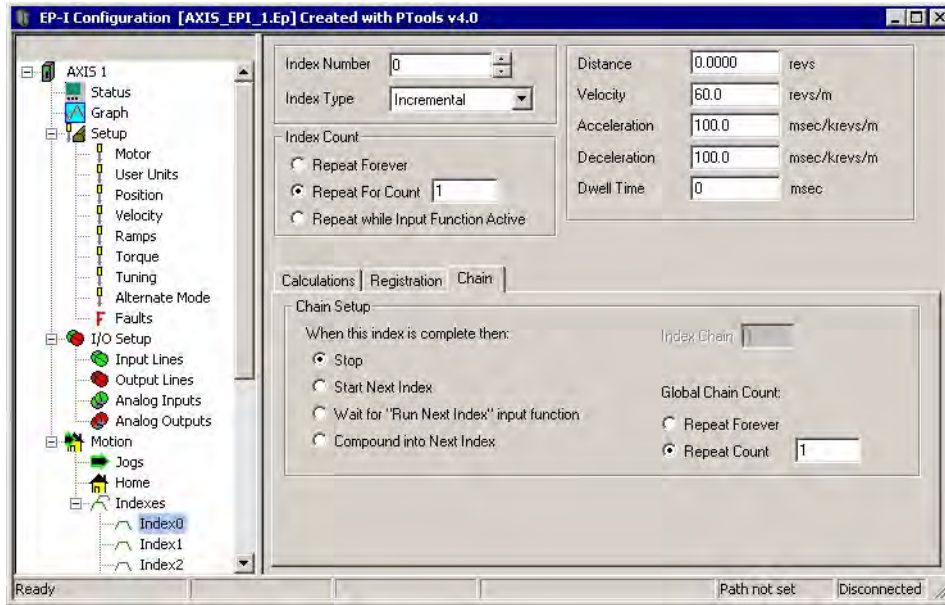


Figure 24: Index View - Chain Tab

### Compound Indexes

This chaining instruction is used to initiate an index which has no deceleration ramp. The index accelerates up to speed and runs at speed until the specified distance is reached. The program then moves on to the next index. It smoothly transitions into the second index without stopping. The second index then ramps to its pre-configured velocity. Multiple indexes can be “compounded” to create a complex velocity profile. The last index in a complex profile must have a deceleration ramp.

Compound indexes are accomplished by selecting the “Compound into” option button located on the Chain tab under the corresponding index.

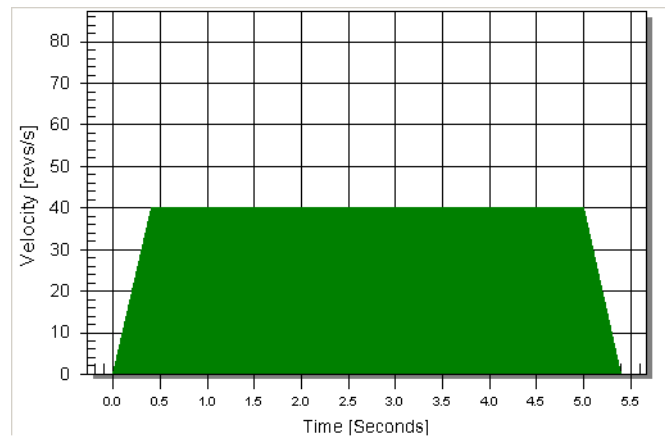


Figure 25: Index 0

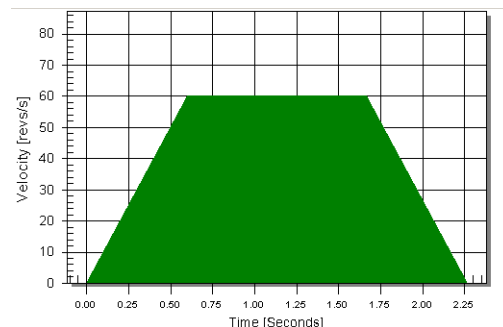


Figure 26: Index 1

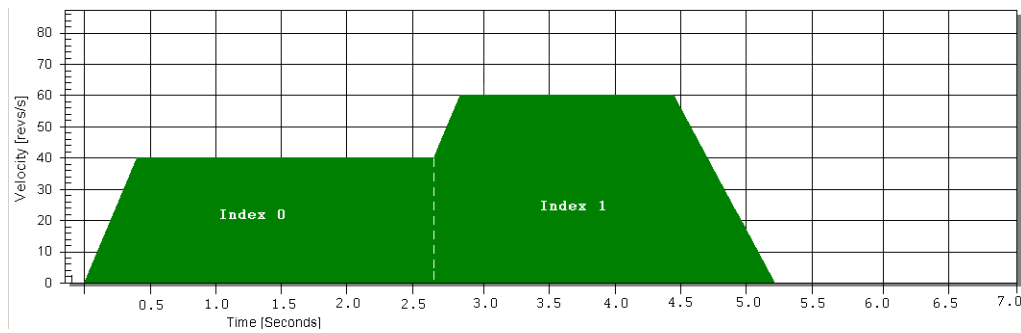


Figure 27: Index 0 Compounded into Index 1

## Status View

This view has two tabs, the Status Online tab displays the drive status in real time and the Information tab displays general information about the drive/module the user is online with.

### Status Online Tab

The information in this view is divided into five categories: Position, Velocity, Torque, Drive Status and Index.

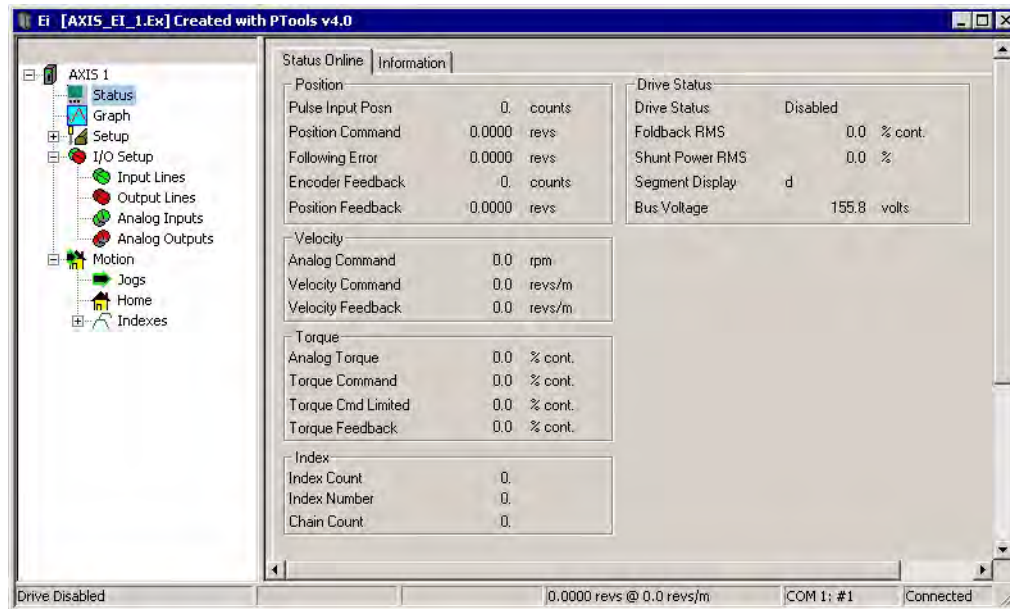


Figure 28: Status View - Status Online Tab - Online

### Note

The information in this view is for diagnostics purposes only and cannot be changed from within this view.

## Position Group

Pulse Input Posn

Position Command

This is the commanded position generated by the device. This is set to zero when the Absolute Position Valid output function is activated.

### Following Error

The Following Error is the difference between the Position Command and the Position Feedback. It is positive when the Position Command is greater than the Position Feedback.

### Encoder Feedback

The motor position in encoder counts since power up when the value was set to zero. This is a signed 32 bit value. This is set to zero when the Absolute Position Valid output function is activated.

### Position Feedback

This is set to zero when the Absolute Position Valid output function is activated.

## Velocity Group

### Analog Command

### Velocity Command

The Velocity Command is the actual command received by the velocity loop.

### Velocity Feedback

This parameter is the actual feedback motor velocity in RPMs.

## Torque Group

### Analog Torque

### Torque Command

This parameter returns the torque command value before it is limited. The torque command may be limited by either the Torque Limit (if the Torque Limit Enable input function is active) or current foldback.

### Torque Cmd Limited

### Torque Feedback

### Actual Command

This is the sum of all torque commands applied in summation mode.

## Drive Status Group

### Drive Status

This reflects the state of the diagnostic LED on the drive. (i.e., Ready, Indexing, Homing, Jogging, etc.).

### Foldback RMS

This parameter accurately models the thermal heating and cooling of the drive and motor. When it reaches 100 percent, current foldback will be activated.

### Shunt Power RMS (Epsilon only)

This parameter models the thermal heating and cooling of the drive internal shunt. This parameter indicates the percent of shunt capacity utilization. When this value reaches 100 percent the drive will generate an RMS Shunt Power Fault.

### Segment Display

Character currently being displayed by the diagnostic display on the front of the drive.

### Bus Voltage

Displays the actual measured voltage on the DC power bus.



## ID Group

### Firmware Revision (Epsilon only)

Displays the revision of the firmware in the drive you are currently online with.

### FM Firmware (FM-2 only)

Displays the revision of the firmware in the drive you are currently online with.

### Serial Number or Drive Serial Number

Displays the serial number of the drive with which you are currently online.

### FM Serial Number (FM-2 only)

Displays the serial number of the FM-2 Module with which you are currently online. This does not apply to Epsilon drives.

### Interface Revision

Displays the application interface revision.

## Time Group

### Total Power Up Time

Total amount of times the drive has been powered up since leaving the factory.

### Power Up Count

Number of times the drive has been powered up since leaving the factory.

### Power Up Time

Amount of time the drive has been powered up since last power up.

## Graph View

The Graph view is only available when online. The Graphing function in the drive makes use of an internal high speed data capture. After this capture is “Arm”ed, the capture will begin to fill a rolling buffer with the data as specified by Channel 1 - Channel 4. Once triggered, the data capture will fill the rest of the allocated memory. After the buffers are completely filled and the trigger activated, the “Upload and Plot” button may be used to upload data which will be displayed in a graphical format.

The User may trigger by entering a trigger level for one of the four channels or using the manual trigger button.

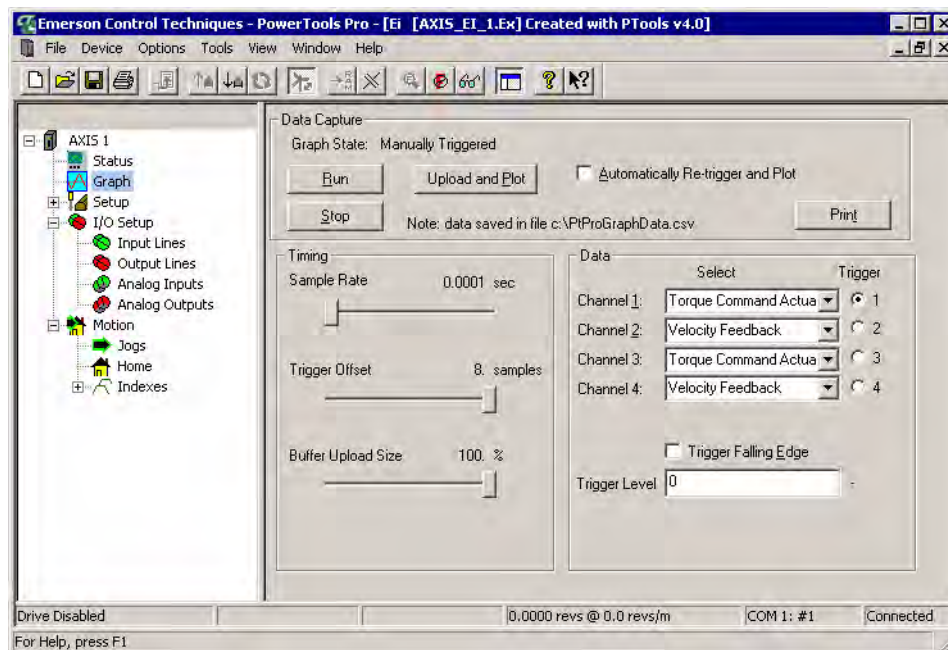


Figure 29: Graph View - Online

## Data Capture

The Data Capture group includes initiate, stop, and graph commands for the graphical monitor.

The “Run” button commands the drive to begin a high speed data capture of the parameters as selected in each of the four data channels. After the Run button is activated the buffer will fill up to the trigger offset while the words “Filling Buffer” appear indicating the Graph State. Once the trigger offset level is reached the words “Waiting Trigger” will appear next to the Graph State indicating that graphical monitor is now ready to be triggered based on the trigger level selected. The Run button may be activated by the letter “R” on the keyboard.

The “Stop” button will stop the high speed data log after it has been initiated and clear out the buffer that this data was previously stored in. The Stop button may be activated by the letter “S” on the keyboard.

The “Upload and Plot” button will upload captured data from the drive and display this data on a graph. The user should wait for the Graph State to read “Triggered” before the data is uploaded.

## Timing Group

The Timing Group includes parameters which control the size, accuracy, and duration of the capture and upload. These parameters may be changed using the slider bars but the drive must be downloaded to in order for these changes to take affect.

### Sample Rate

The Sample rate slider gives the user control of time spacing for the captured data. To give the user a better idea of what this number means, the total number of samples and total capture time is displayed on the bottom of this Timing group.

### Trigger Offset

This slider corresponds to the number of samples that will be included on the graph display and data capture prior to the actual trigger. If the Trigger offset slider is completely to the left (min samples), the data capture and graphing will start at the trigger location. If the slider is completely to the right (max samples) the graph will capture data until the trigger point.

### Buffer Upload Size

In the instance that a user would like to save time in an upload, the buffer upload size slider truncates the drive captured data. If the slider is completely to the right (max) the complete buffer will be uploaded. If the slider is completely to the left, only 1% of the buffer will be uploaded.

## Data Group

The Data Group is used to select which parameters will be graphed as well as which parameter will be used as the data trigger. If a change is made to any parameters within the Data Group, this change must be sent to the drive via a download.

### Channel 1 - 4

Channel 1 through Channel 4 give the user options for parameter display. If parameters with the same units are mapped on adjacent channels then the graphical display will show these two parameters overlapped on the same x/y axis. If it is desirable to have two adjacent Channels mapped to separate axis on the graph then the selection (none) should be used on the channel in between these two parameters.

### Trigger

Selecting the trigger option button to the right of the channel will cause the graphical capture to trigger the capture off of that Channel. The “Trigger Level” text box on the bottom of the display will change units to accommodate the selected channels user units. This trigger level may be changed at any time but the change must be sent to the drive via the “update” or “download” button. If a manual trigger is desired, set the channel to “None” and select the corresponding trigger option button. If no trigger is selected the capture will begin when “Run” is clicked and end at the end of the Sample Rate.

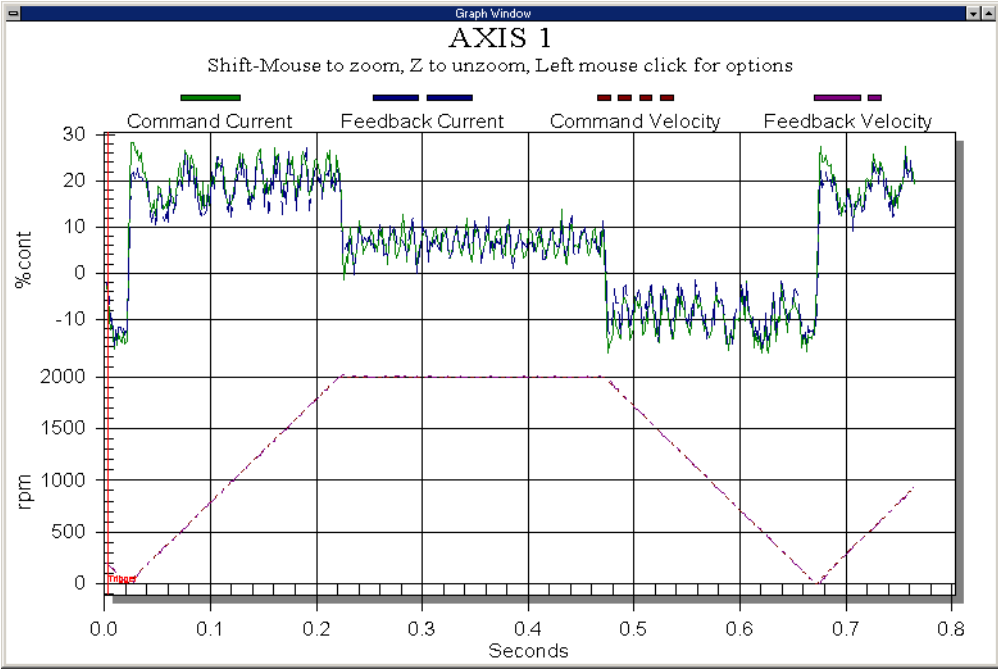


Figure 30: Graphical Plot



# Operational Overview

The FM-2 Module augments the base drive by providing single axis position control. When an FM-2 Module is attached to a base drive, it overrides the operation and user accessible features of the drive. The base drive's basic operating mode, Torque Presets is not available when a FM-2 Module is attached.

The Epsilon EP-I Indexing Drive and FM-2 Indexing Module allow you to setup 16 different indexes, Slow and Fast Jog functions and a single Home routine. They also provide eight digital input lines and four digital output lines in addition to the four input and three output lines available on the drive.

## User Interface

The Epsilon EP-I Indexing Drive and FM-2 Indexing Module are set up using PowerTools Pro software. PowerTools Pro is an easy-to-use Windows-based setup and diagnostics tool. It provides you with the ability to create, edit and maintain your drive's setup. You can download or upload your setup data to or from a device. You can also save it to a file on your PC or print it for review or permanent storage.

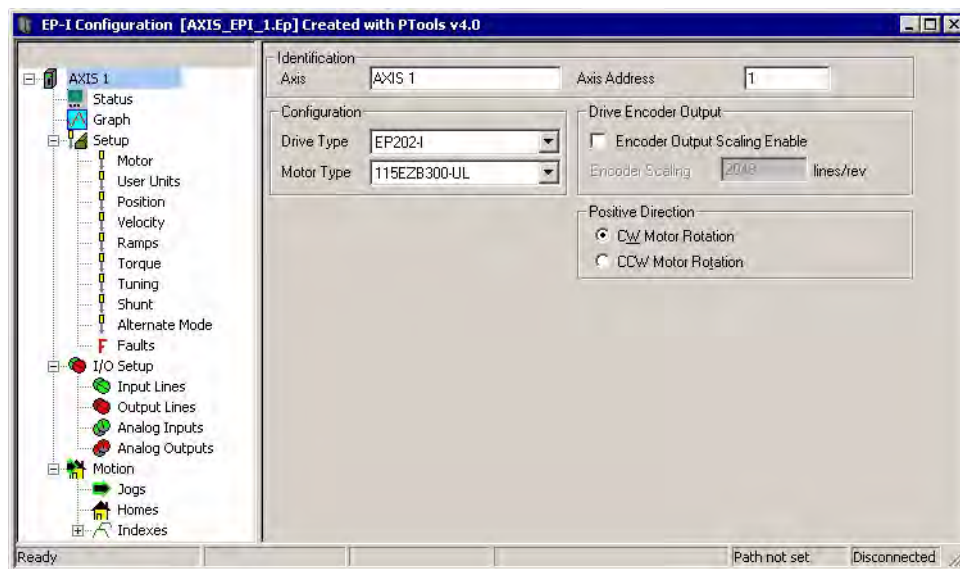


Figure 31: PowerTools Pro Setup View For An Epsilon EP-I Drive

## How Motion Works

The Epsilon EP-I Indexing Drive and FM-2 Indexing Module provides six types of motion: jogging, home, indexing and with alternate mode, analog velocity, analog torque and pulse mode. Only one type of motion may be in process at any given moment. With all EP-I drives and the FM-2 modules motion can be initiated by input assignments or thru PowerTools Pro or over a network like DeviceNet using an EP-IDN drive. The FM-2 Module can sequentially run various motion routines by use of chained indexes or I/O assignments.

## How Jogging Works

The Jog functions produce rotation of the motor at controlled velocities in the positive or negative direction. Jogging is initiated using the Jog + and Jog - input functions.

Assignments to jogs are level sensitive such that when the jog input is turned "On", jogging begins and continues jogging until the jog input is removed.

When Jog + goes "On" the axis ramps up to speed and continues at speed. When Jog + goes "Off" the axis decelerates to a stop.

Jog has acceleration and deceleration ramps along with specified velocities. Jogging has no distance parameter associated with it. If trying to move a specific distance or to a known position, then an index is used.

Jogging in the opposite direction will move off a travel limit (use Jog + to move off a Travel Limit -).

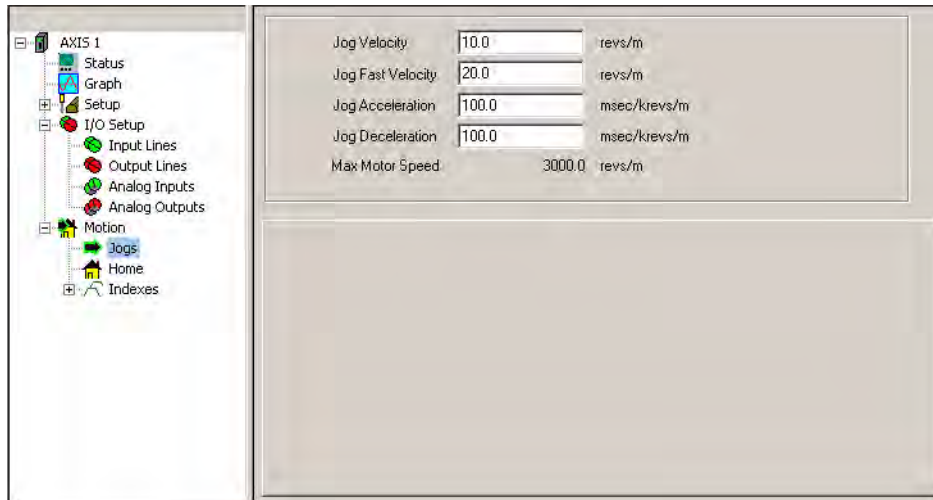


Figure 32: Jog View

### Jog and Jog Fast Velocity

The Jog Velocity parameter specifies the velocity used for jogging with the Jog + or Jog - input functions.

The Jog Fast Velocity parameter specifies the velocity used for fast jogging with the Jog Fast input function in conjunction with either the Jog + or Jog - input function.

### Jog Acceleration and Deceleration

Jog acceleration and deceleration are in units of revs/ or user unit/sec<sup>2</sup>, depending on which Time Scale was selected on the User Units View. The default value for both is 1000 ms/kRPM. For example, at the default values, if you initiated a Jog with a velocity of 500 RPM, the motor will accelerate to 500 RPM in 0.5 seconds.

$$\begin{aligned} \text{Accel Time} &= 500 \text{ RPM} \times 1000 \text{ ms/kRPM} \times 1 \text{ kRPM}/1000 \text{ RPM} \\ &= 500 \text{ msec} = 0.5 \text{ sec} \end{aligned}$$

## Jog Input Functions

The device has three input functions available which are used to initiate four different jogging operations: Jog+, Jog-, Jog Fast + and Jog Fast -.

---

### Note

In the table below Jog Velocity = 100 RPM and Jog Fast Velocity = 500 RPM.

---

Jog +	Jog -	Jog Fast	Motion
Off	Off	Off	0 RPM
On	Off	Off	+100 RPM
Off	On	Off	-100 RPM
On	Off	On	+500 RPM
Off	On	On	-500 RPM
On	On	Off	0 RPM
On	On	On	0 RPM

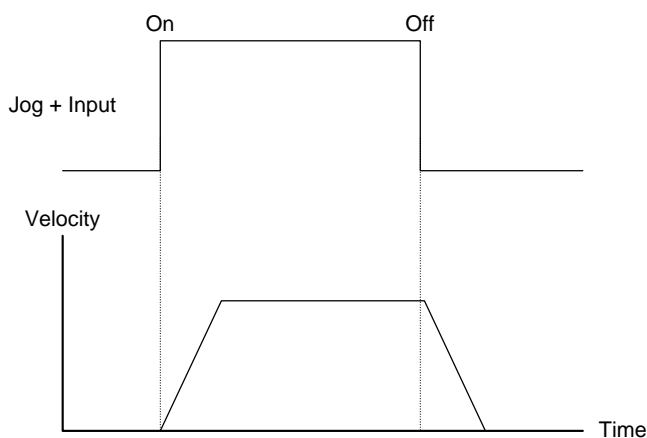


Figure 33: Jog Input

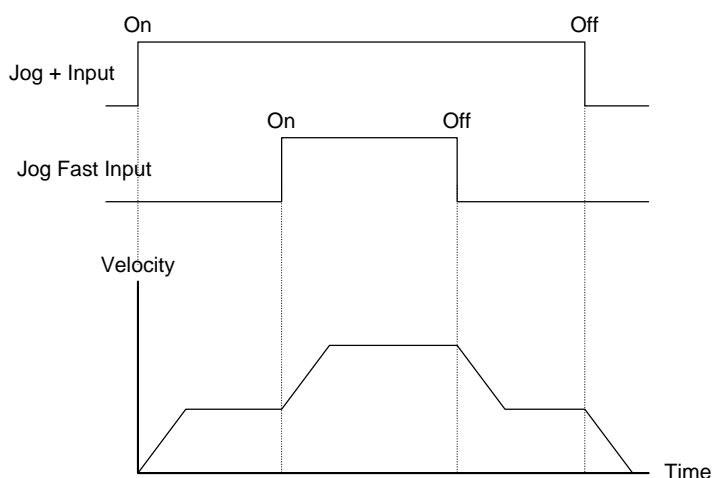


Figure 34: Jog Input and Jog Fast Input

When the Jog Fast input function is not active, the target velocity for the jog is the Jog Velocity. If the Jog Fast input function is active, the target velocity of the jog is the Jog Fast Velocity. Jog Fast can be toggled “On” or “Off” while jogging. Jog acceleration and deceleration ramps are used to ramp between jog velocities.

If the Jog direction is reversed, the Jog deceleration value will be used to decelerate the motor to zero speed and then the Jog acceleration will be used to accelerate to the new (opposite sign) velocity.

---

## Note

The Jog function cannot be initiated when any other motion type (homing, indexing) is in progress.

---

If both jog input functions are “On” there is no motion after a jog deceleration (they effectively cancel each other). The drive’s display will show “R”, for ready.

If the device is jogging with the Jog + Input function “On” and the Jog - Input function goes active, the device behaves the same as if it would in Jog + just turned “Off”.

The Stop input function will override the Jog operation and decelerate the motor to zero speed.

If the motor reaches a Travel Limit, you can Jog off the Travel Limit in the opposite direction. (Use Jog + to move off a Travel Limit -).

## How Home Works

The Home routine is used in applications in which the axis must be precisely aligned with some part of the machine. The Home routine is initiated with the Home Initiate Input Function.

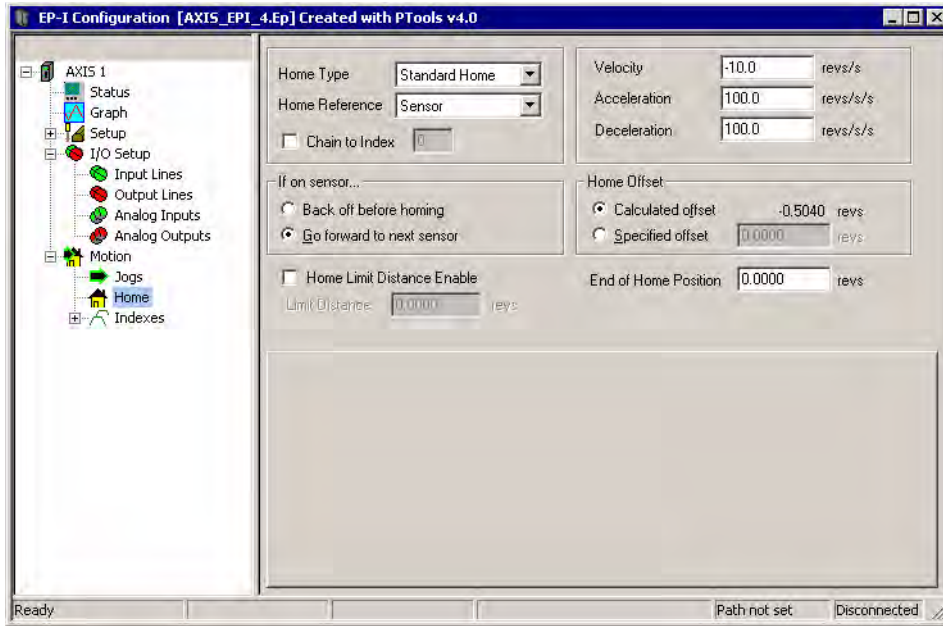


Figure 35: Home View

## Home Type

The first step in setting up a home routine is to select the desired home type.

### Standard Home

The device can home the motor to an external sensor, the motor's encoder marker pulse or to a sensor and then to the encoder marker pulse.

### One Side Home

The one side home is designed to add power to simple indexing applications where the machine can be stopped and re-homed from either side of the home sensor.

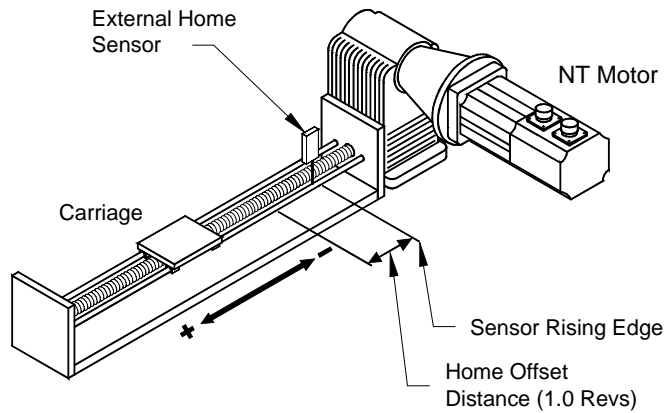


Figure 36: Basic Standard Home Function

The figure above shows a basic standard home function using a ball screw. This example uses most of the setup features in the PowerTools Pro Home View.



## Standard Home Sequence

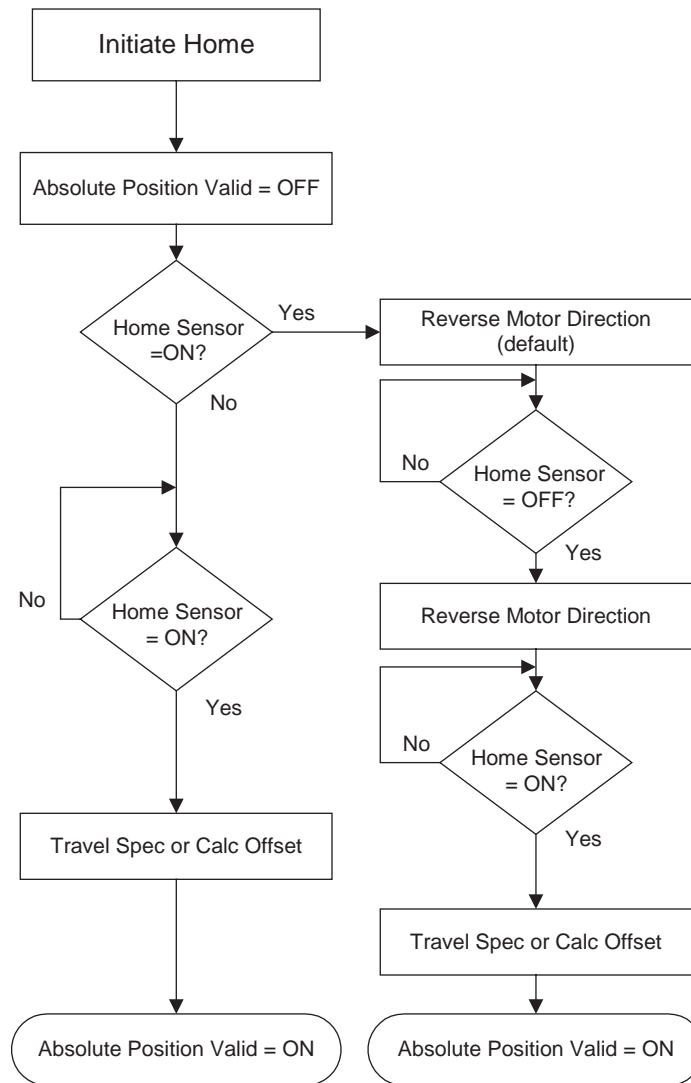


Figure 37: Flow Chart of a Standard Home Routine

Homing to the motor's encoder marker will establish the most accurate and repeatable home position. This method will position the motor relative to the location of the rising edge of the encoder marker pulse. Most applications will use a sensor and marker to find an accurate home position in the vicinity of the home sensor.

## One Side Home Sequence

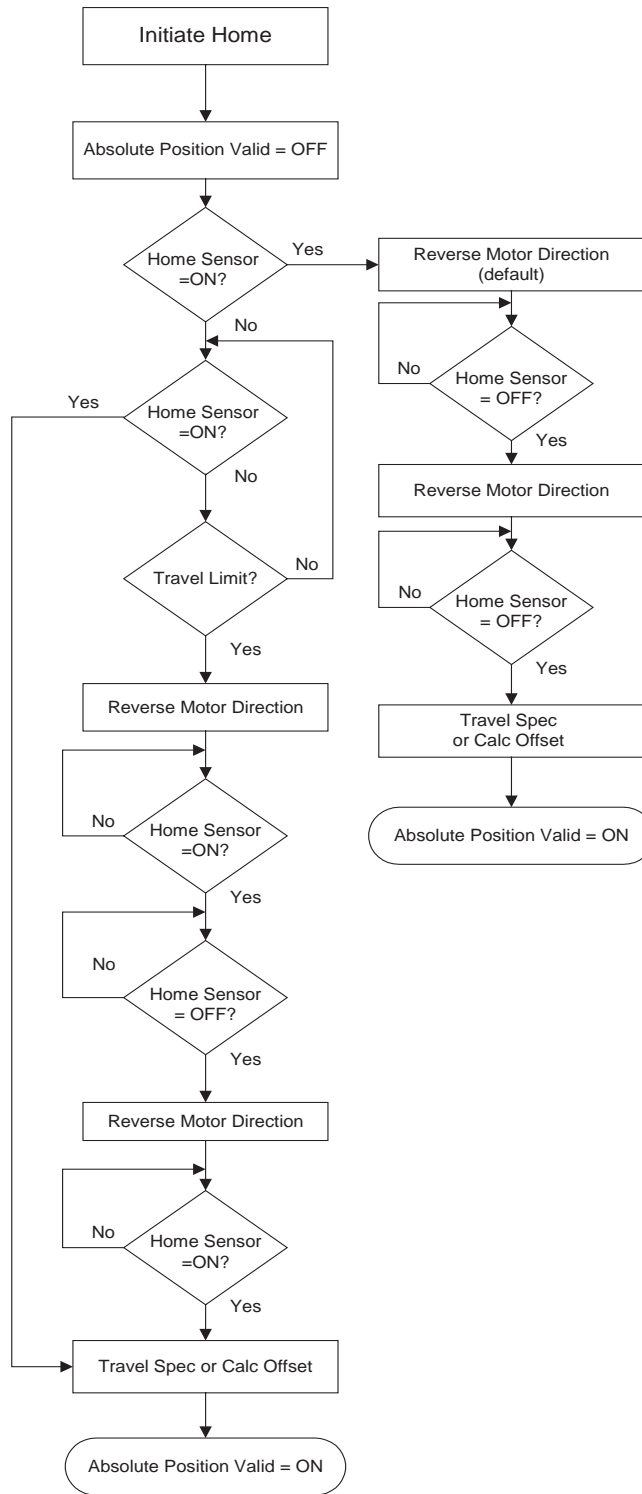


Figure 38: Flow Chart of a One Side Home Routine

Several parameters (including input and output functions) affect how the Home function operates. Each of these parameters are explained in detail on the following pages.

### Note

The Home function will NOT be initiated when any other motion command is in progress.

## Establishing a Home Reference Position

The second step in setting up a home routine is to select the desired home reference type. The Home Reference parameter selected determines how the Home Reference Position is established. PowerTools Pro allows selection of one of three different Home References: Sensor, Marker, or Sensor and Marker for a Standard Home and Sensor for a One Side Home.

### Sensor

Selecting Sensor means the rising edge of the Home Sensor input function is used to establish the home reference position.

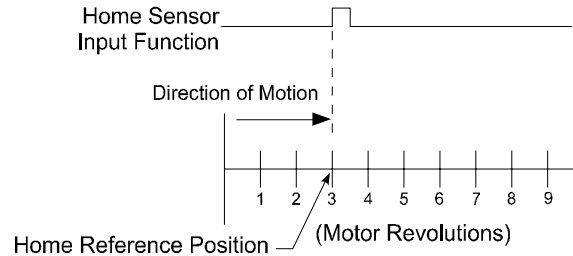


Figure 39: Sensor Home Reference Position

### Marker (Standard Home only)

Selecting Marker means the rising edge of the motor's encoder marker channel is used to establish the reference position.

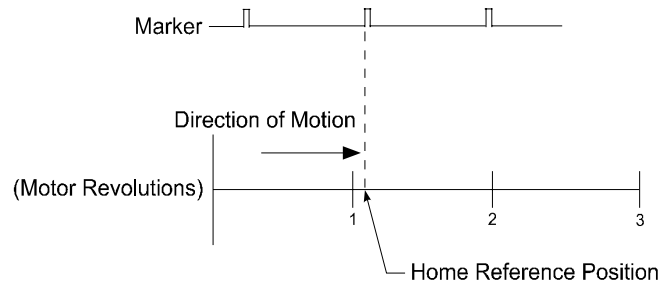


Figure 40: Marker Home Reference Position

### Sensor and Marker (Standard Home only)

Selecting Sensor and Marker means the reference position is established using the first marker rising edge after the device sees the rising edge of the Home Sensor input function.

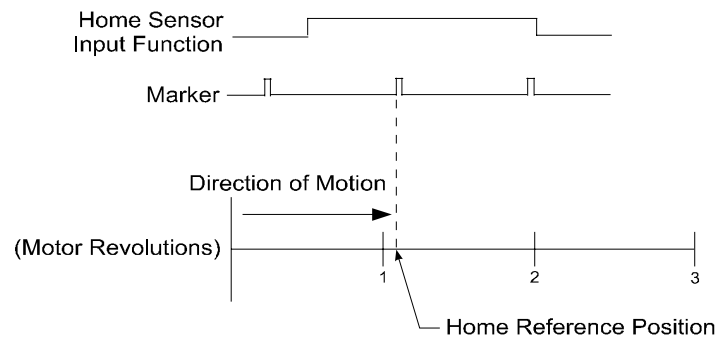


Figure 41: Sensor and Marker Home Reference Position

## Accuracy and Repeatability

The amount of accuracy your application requires will determine the Home Reference option you select. Homing to an external sensor only will establish a repeatable home position within 0.0025 revolutions at 3000 RPMs (50 msec sensor capture interval).

**Note**

The data above assumes the use of a perfectly repeatable home sensor.

Sensor and Marker, and Marker home types will establish a repeatable home position within one encoder count at any motor velocity.

**Note**

The one encoder count factor assumes the motor is approaching the marker from the same direction. If different directions are used, the final home position will be off by four encoder counts (0.000488 revolutions).

In Sensor and Marker applications, the marker must be at least 800  $\mu$ s after the rising edge of the sensor input to be considered a valid marker pulse.

**Note**

At 1000 RPM, the motor will travel 0.0133 revolutions (or 4.8°) in 800  $\mu$ s.

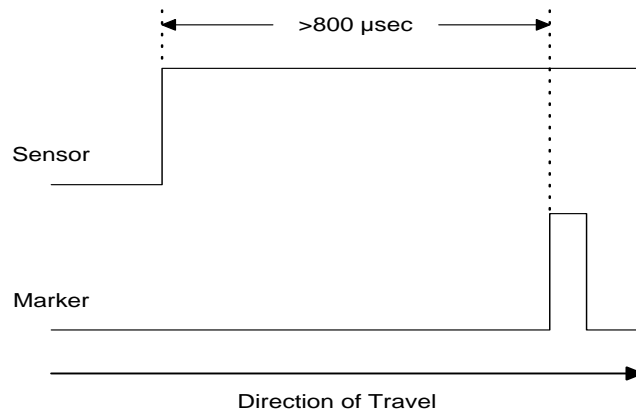


Figure 42: Sensor and Marker Position

The Home Sensor must be “On” for at least 50  $\mu$ sec to guarantee that it will be recognized.

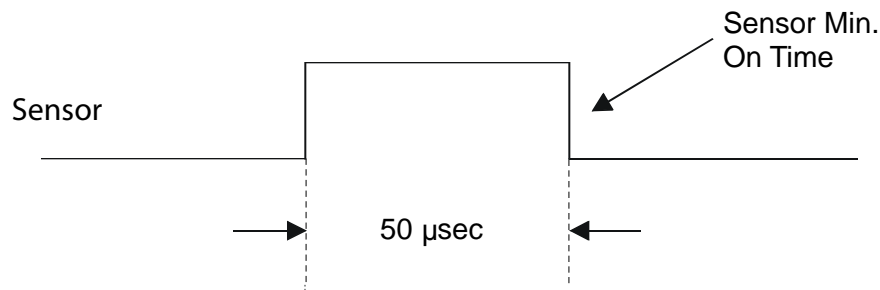


Figure 43: Sensor Position

**Home Offset**

The Home Offset is the distance from the Reference Position to the final stopping point at the end of the homing sequence. Regardless of the value you enter for the Offset or which Home Reference you choose, an offset is always inherent in the homing process.

The user may either specify a desired offset or allow the drive to calculate an offset automatically. The drive calculates an offset that ensures that the motor will not have to backup to get to the offset position. This is very convenient for unidirectional applications.

The calculated offset is the distance travelled during deceleration ramp from the home velocity to a stop plus the distance travelled at the home velocity for 400 $\mu$ s. This extra distance is used to guarantee that the motor will not need to backup after the deceleration ramp.

The Specified Offset allows the user to choose an exact offset from the Home Reference.

Once the home reference is detected, the device will do whatever is necessary to reach the offset position. This may be as simple as a deceleration to a stop, a continuation at speed followed by a deceleration to a stop, or a deceleration followed by a move in the opposite direction.

To enter a specified home offset, select the Specified Offset option button. PowerTools Pro always displays the calculated offset value as a reference.

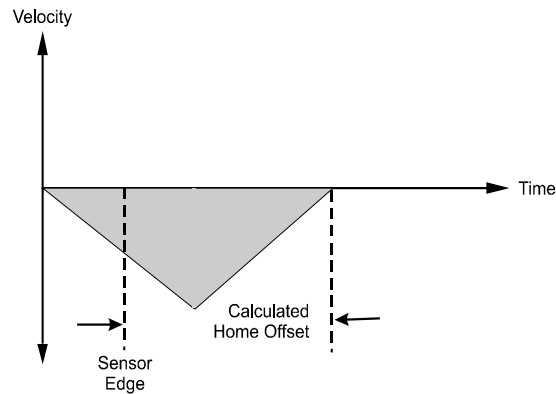


Figure 44: Specified Home Offset

---

### Note

If the home reference is detected before the axis has reached its peak velocity, the axis will still continue to the precise offset position.

---

## Home Offset Examples

The following three home cycle examples each use a different offset method or value.

### Example 1: Calculated Offset

In the example below, a calculated offset is used.

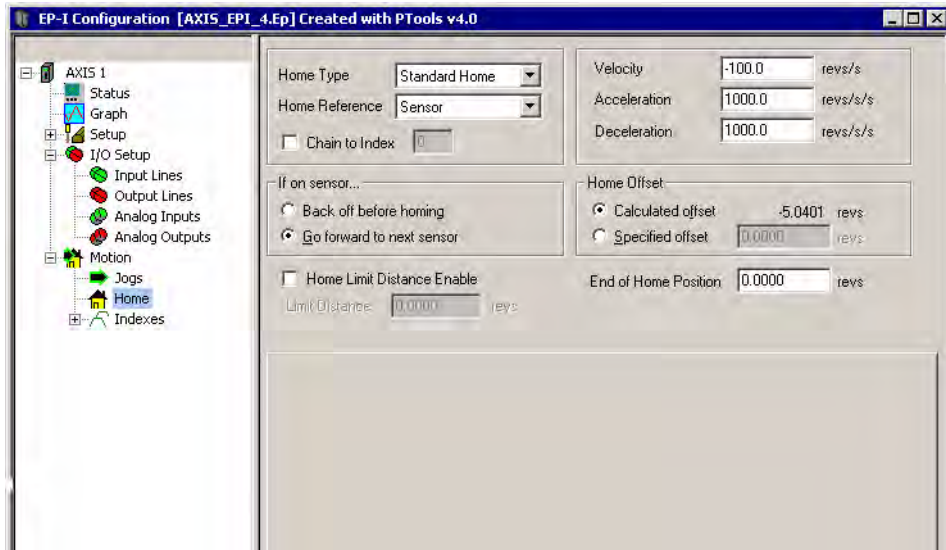


Figure 45: Calculated Offset Screen

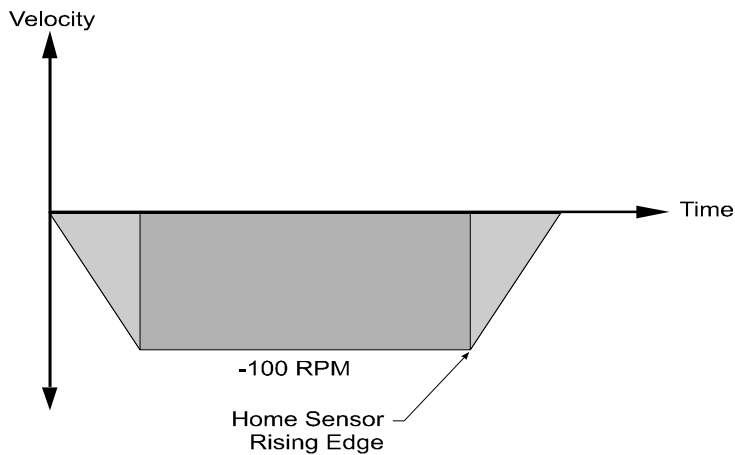


Figure 46: Calculated Offset

### Example 2: Specified Offset, Greater than Calculated Offset

In the example below the specified offset is larger than the calculated offset. This causes the axis to continue on at speed before decelerating and stopping at the offset position.

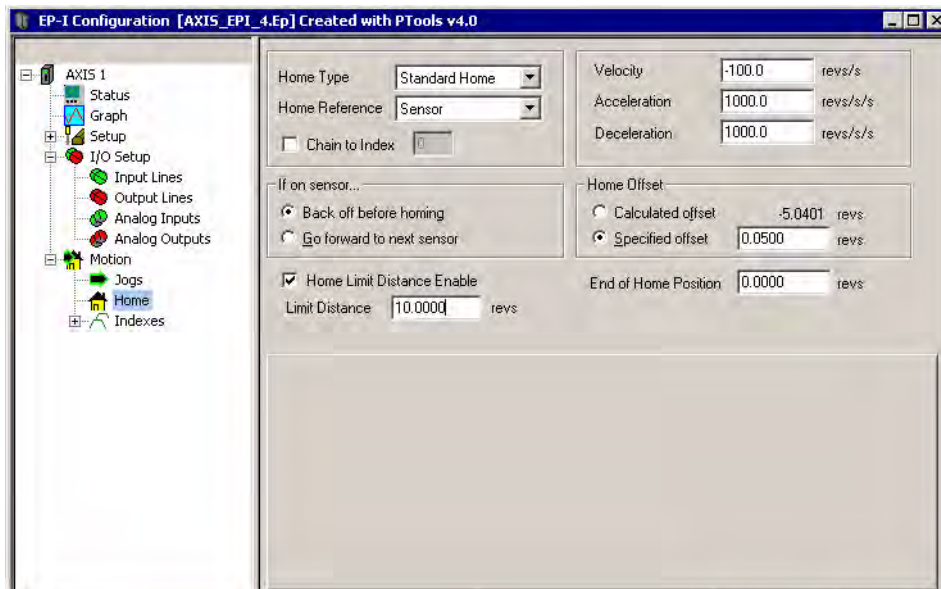


Figure 47: Specified Offset Screen

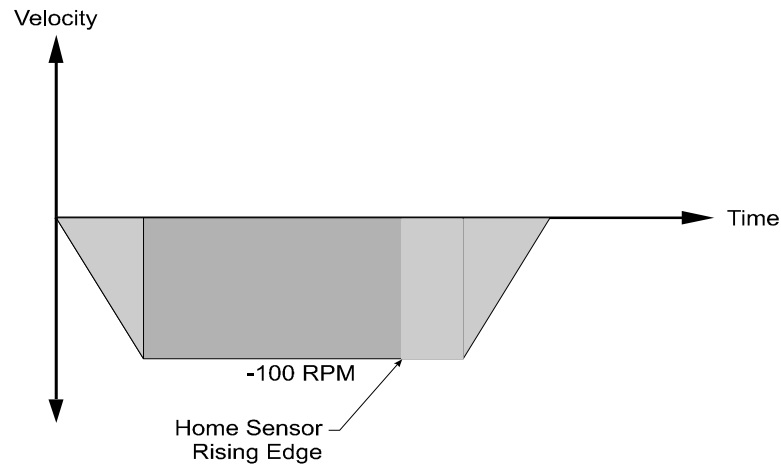


Figure 48: Specified Offset, Greater than Calculated Offset

**Example 3: Specified Offset, Back up Required**

In the example below the specified offset is located such that the motor must stop and back up to get to the offset position.

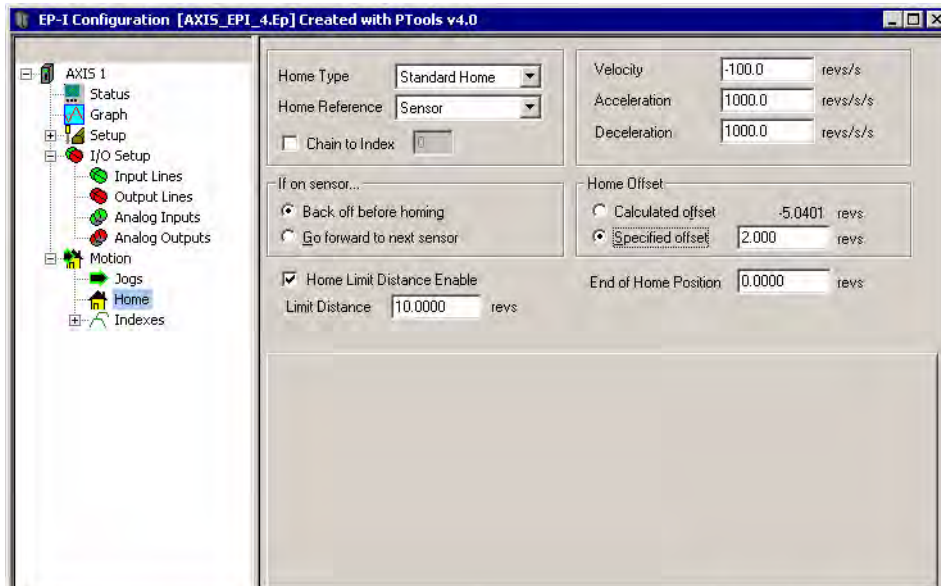


Figure 49: Specified Offset Screen

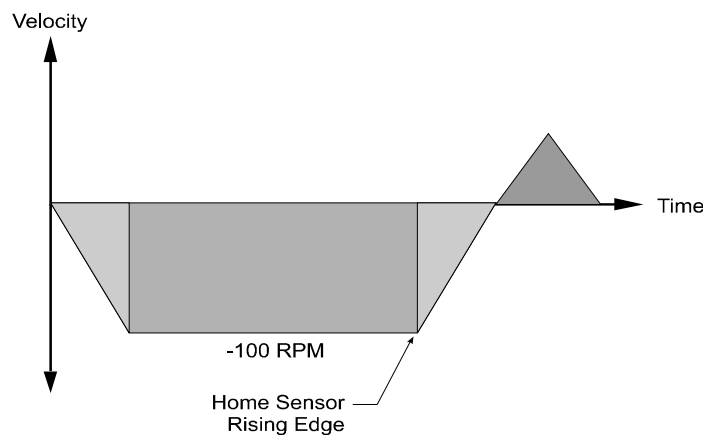


Figure 50: Specified Offset, Backup Required

**End of Home Position**

The End of Home Position defines the home position in relation to the machine’s coordinate system. At the completion of the home routine, the value of the End of Home Position is put into the command and feedback positions.

**Home Limit Distance**

This parameter places an upper limit on the incremental distance the motor will travel during the home routine.

If no reference is found the system will decelerate and stop at the limit distance. The Home Limit Distance Hit output function will be activated if the home stops at the limit distance without finding the reference. Additionally, the End of Home output will not turn “On” if the limit distance is hit.

**Moving Off Sensor Before Homing**

In applications that use a sensor (or sensor and marker) to establish a Home Reference Position, there may be situations where the home sensor input is active when the home cycle is initiated. The device can either back off the sensor before homing or go forward to the rising edge of the next sensor.



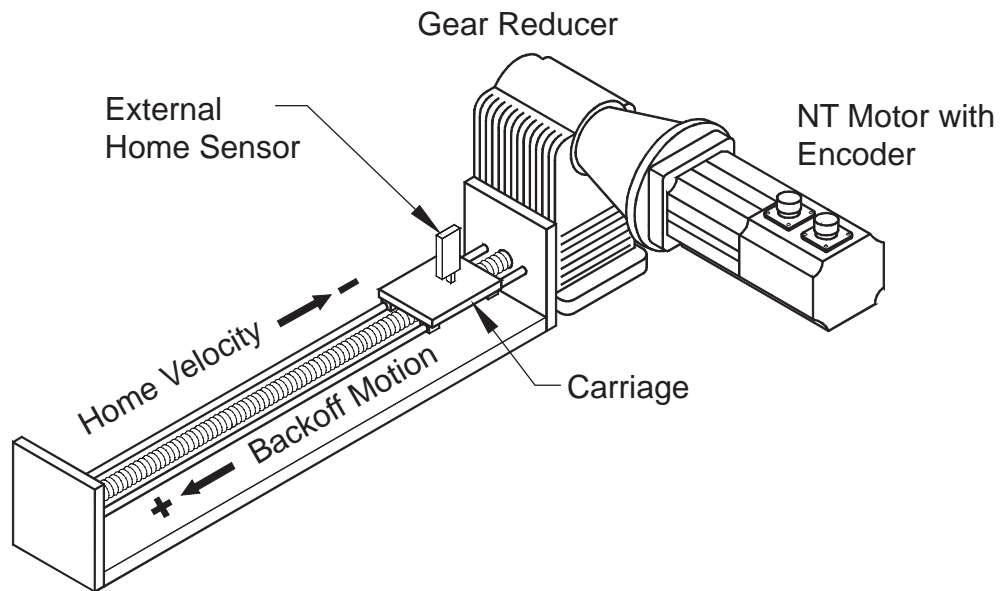


Figure 51: Back Off Sensor Example

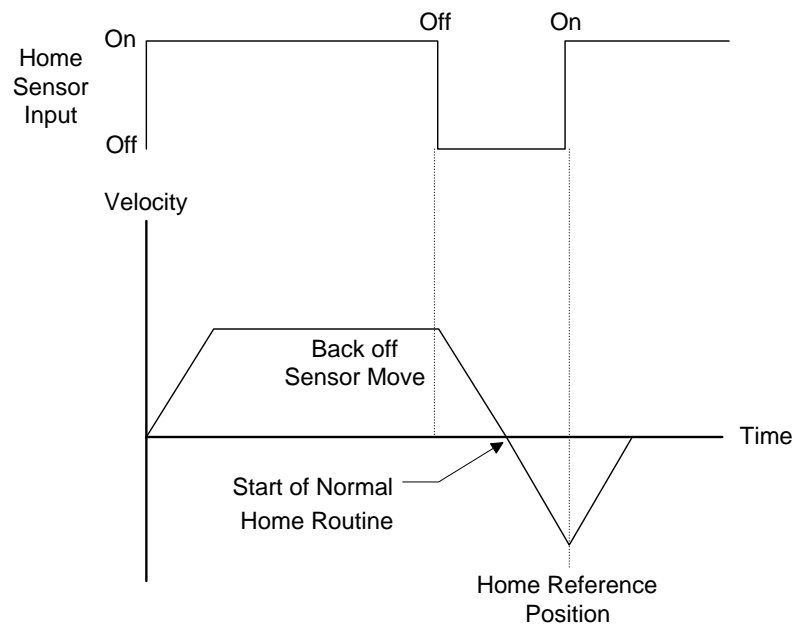


Figure 52: Back Off Sensor

In the figure on the previous page, the motor has restricted travel. In order to find the rising edge of the Home Sensor input, the motor must back away from the sensor until the Home Sensor Input Function deactivates, then move forward looking for the rising edge of the sensor. When backing-off of the sensor, the motor will move in the opposite direction of the Home Velocity.

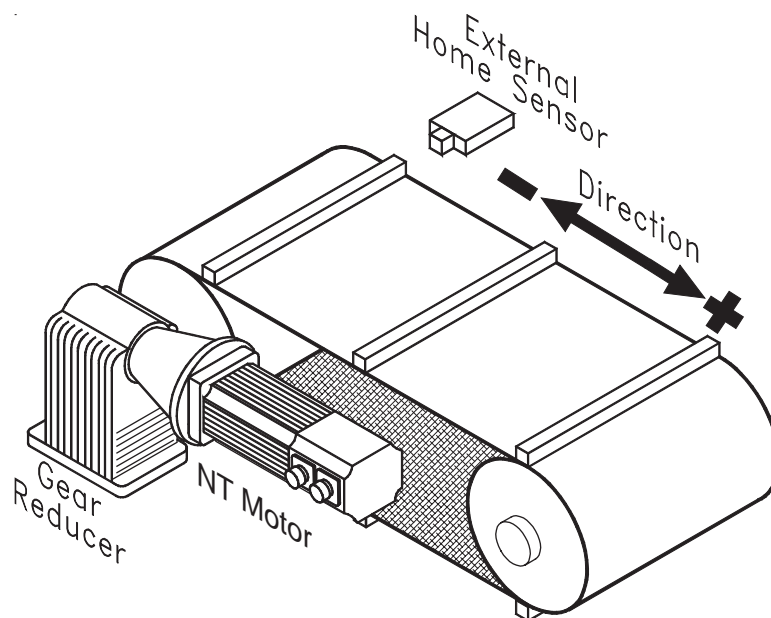


Figure 53: Move Forward Off Sensor Example

In the application shown above we will assume that the motor can only move in the positive (+) direction. The Home Sensor input can be triggered by any one of the spacer lugs on the belt. If the Home Sensor input is active when the device receives a Home Initiate, the motor would move forward off the sensor and continues on until it finds the rising edge of the next Home Sensor input.

## Home Input and Output Functions

### Input Functions

#### Home Initiate

The Home Initiate input function is used to initiate the home function. The Home is initiated on the rising edge of this input function. The device will not initiate a Home if there is an Index or Jog in progress or if the Stop input function is active or if a travel limit is active.

#### Home Sensor

This input function defines the sensor used for homing. It is required if you are homing to a sensor. This function is edge sensitive. The sensor position is determined when the Home Sensor Input Function is activated.

If the device receives a Home Initiate input while the Home Sensor input is active, you can choose to have the motor “back-off” of the home sensor before it initiates the home function.

If debounce is used on the Home Sensor Input Function, the debounce determines the length of time the input must be active to be considered a valid input. The rising edge of the sensor is still used for the reference position. This maintains accuracy while providing the ability to ignore false inputs.

#### Define Home

This input function is used to manually define the home position using an input function. When this input function is activated, the command and feedback positions will be set to zero. The Absolute Position Valid output function is activated by the Define Home input function.

### Output Functions

#### End of Home

This output function is used to indicate that a home cycle has been successfully completed. This output function is deactivated when any Index, Home, or Jog is initiated.

### Home Limit Distance Hit

This output function indicates that no home reference was found while traveling to the Home Limit Distance. The device will decelerate and stop at the Home Limit Distance. This output function is activated when the motor stops. It is deactivated when any index, home or jog is initiated.

### Absolute Position Valid

This output function is activated when a Home Routine is successfully completed or the Define Home Input Function is activated. It indicates that the device has been homed. It is cleared by the Home Initiate, an encoder fault and when the device is powered down.

## Home Examples

### Example 1: Linear Application

In this example, the device uses an external sensor and the motor's encoder marker channel to establish a Home Reference Position. This is the most accurate and most common way to home.

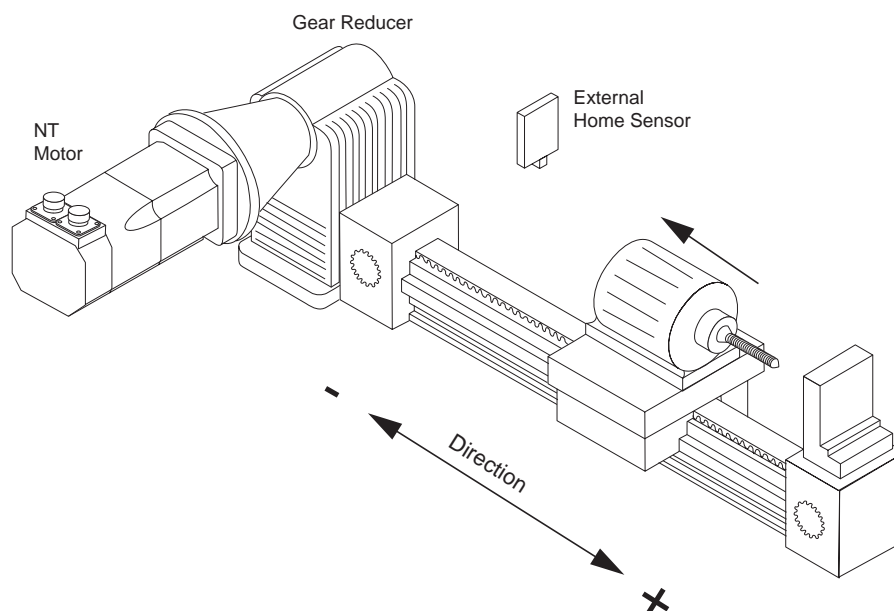


Figure 54: Home to Sensor and Marker

When the device sees the rising edge of the Home Initiate input, it accelerates the motor to the Home Velocity.

The motor continues at that velocity until it first senses the Home Sensor input. It continues at the same velocity until the motor's encoder marker channel is sensed. The rising edge of the motor's encoder marker channel is used to establish the reference position.

Once the home reference (marker) is detected, the motor decelerates to a stop and moves to the offset position.

### Home Sequence

1. If on sensor then back off
2. Search for sensor
3. Search for marker
4. Go to offset
5. Set position to End of Home Position

The figure below shows how the PowerTools Pro Home view was setup for this example.

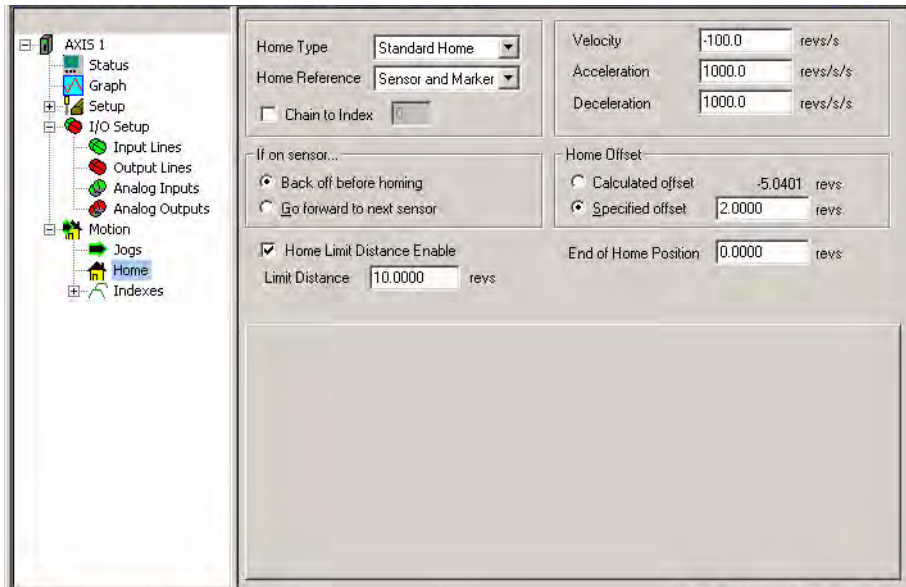


Figure 55: Home Screen, Sensor and Marker Selected

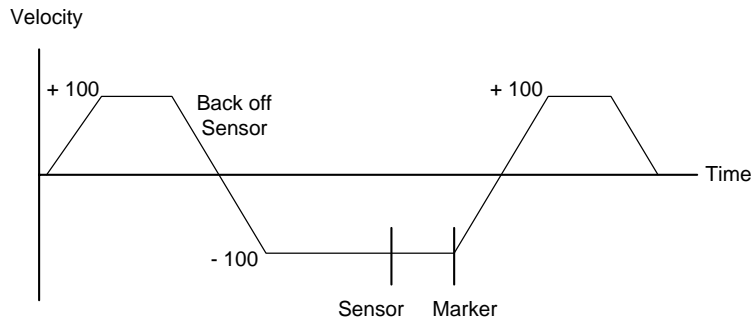


Figure 56: Home Velocity Profile

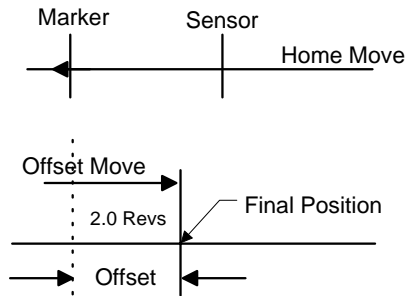


Figure 57: Home Move Sequence

Example 2: Rotary Application

This example uses an external sensor and the motor's encoder marker pulse to establish a home reference position.

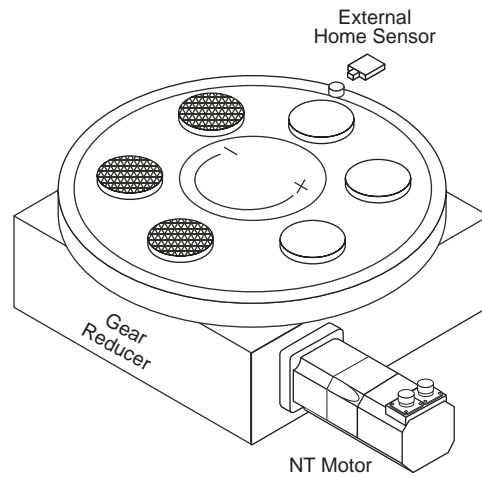


Figure 58: Sensor and Marker then Offset

When the device sees the rising edge of the Home Initiate input function, it accelerates the motor to the Home Velocity. The motor continues at that velocity until it first senses the Home Sensor input. The motor continues on at the home velocity until the marker is activated.

The rising edge of the motor's encoder marker channel is used to establish the reference position.

After sensing the rising edge of the motor's marker channel, the device will continue moving and will decelerate to a stop at the specified offset position.

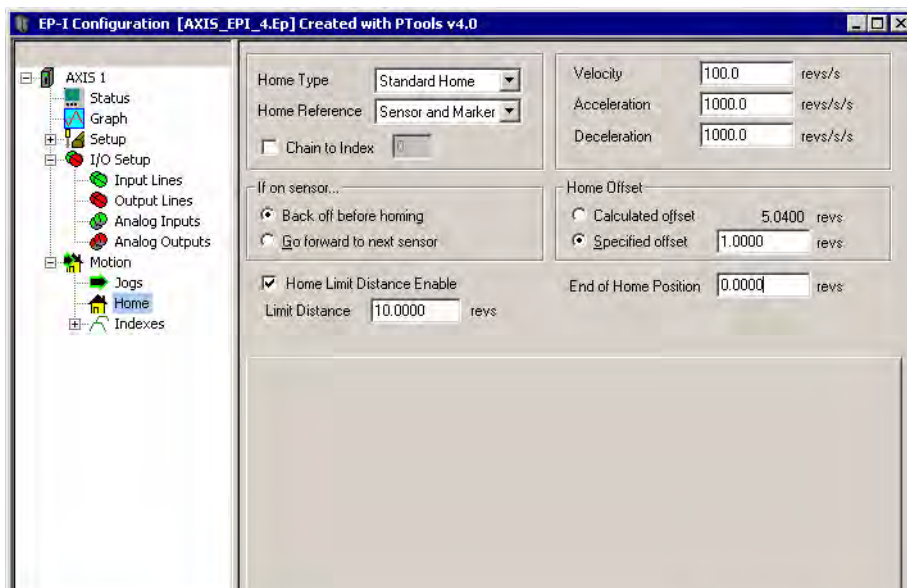


Figure 59: Sensor and Marker then Offset Screen

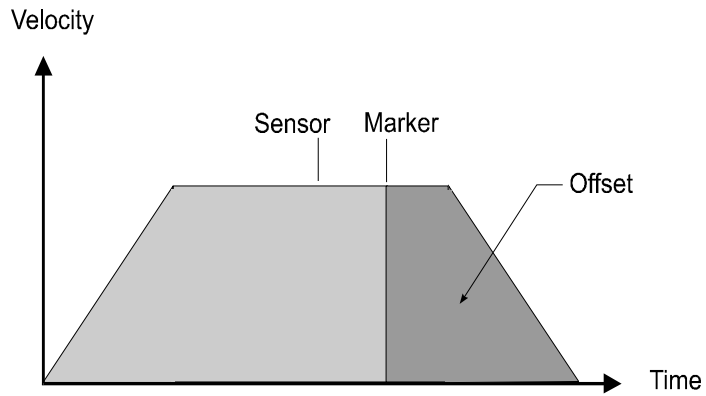


Figure 60: Home Velocity Profile

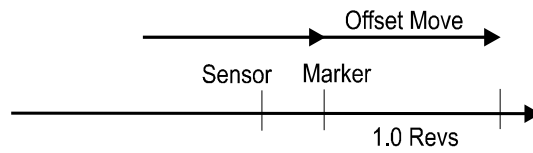


Figure 61: Home Move Sequence

## How Indexes Work

An index is a complete motion sequence that moves the motor a specific incremental distance or to an absolute position. This motion sequence includes an acceleration ramp to a programmed velocity, a run at velocity, a deceleration to a stop, and a dwell time.

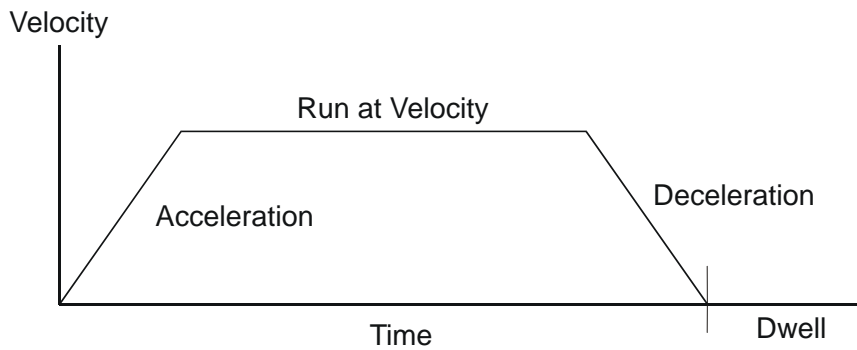


Figure 62: Complete Motion Sequence

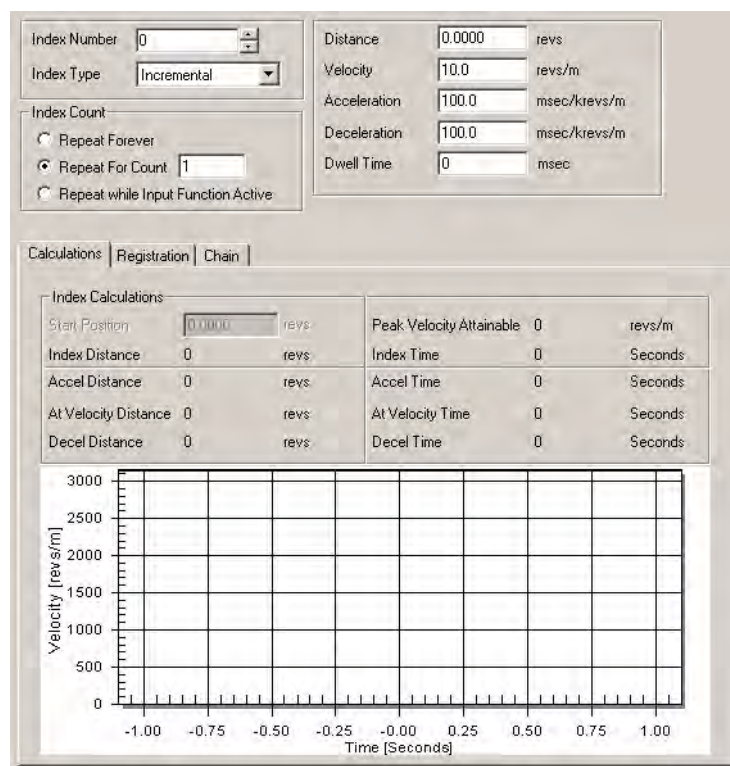


Figure 63: Index 0 View

All Indexes use linear acceleration and deceleration ramps which may or may not reach the specified velocity depending on the total distance and the ramp values. For example, a short move with long acceleration and deceleration ramps may not reach the peak velocity entered.

Indexes cannot be initiated when any other motion (jogging, homing) is in progress. Indexes can be aborted with the Stop Input function.

## Index Type

The device supports five types of indexes: Absolute, Incremental, Registration, Rotary plus, and Rotary minus.

### Absolute vs. Incremental

The difference between absolute and incremental indexes is that absolute indexes move to a specific absolute position and incremental indexes move the motor a specific distance. The figures and explanations below demonstrate this concept.

#### Absolute Indexes

Absolute indexes are used in applications where the motor must travel to a specific position, regardless of where the motor is when the index is initiated.

The device calculates the distance required to move to the specified position from the current position.

##### Absolute Index

Start position = 6

Absolute index position = 4

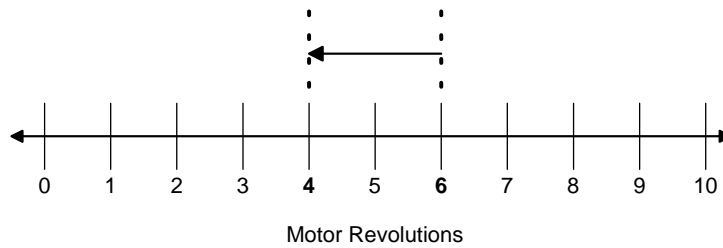


Figure 64: Absolute Index

In the example above, the index position is 4 revs. If this index is initiated the motor will travel to a position of 4 revs no matter where it is sitting before the move. From 6 revs, it will travel -2 revs. If the absolute index to 4 revs is initiated a second time, no motion will occur because the motor will already be at a position of 4 revs.

The direction of an Absolute Index is determined by the starting position and the absolute index position. If the starting position for the above index is 9 revs, then the motor will rotate in the negative direction to end up at 4 revs.

Absolute Indexes with Rotary Rollover enabled will take the shortest path to the position entered in the index position parameter.

---

**Note**

Absolute indexes move to positions relative to where the machine was homed using the home routine.

---

**Incremental Indexes**

An incremental index will move the motor a specified distance in the + or - direction regardless of the starting position. The direction of the incremental index motion is determined by the sign (+ or -) of the Index Distance parameter.

**Incremental Index**

Start position = 6

Index distance = 4

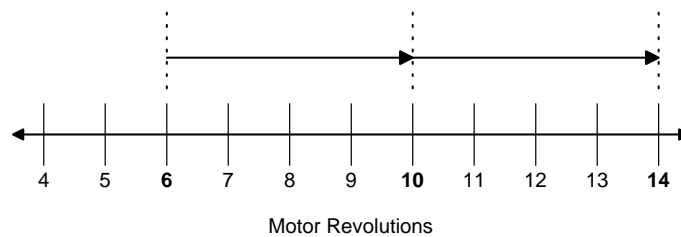


Figure 65: Incremental Index

In the example above the motor starts at 6 revs and travels a distance of 4 revs and stops at 10 revs. If the same index is initiated a second time the system would move another 4 revs to a final position of 14 revs.

**Registration Indexes**

A Registration Index is used in applications where the motor must move until an object is detected and then move a specific distance from the point of detection, such as finding a registration mark and moving a distance beyond.

The Registration Index consists of two parts. The first part accelerates the motor to the target velocity and continues at this velocity until it receives a registration trigger (sensor or torque). Upon receipt of a registration trigger, the registration offset will be executed at the target velocity. The Sensor Limit Distance Hit source can be used to turn on an output, if a sensor input or torque level is not received within the Limit Distance.

**Rotary Plus and Rotary Minus Indexes**

Rotary Plus and Rotary Minus Indexes provide forced directional control of moves to absolute positions. The position entered for a Rotary Plus or Minus type index must be within the rotary range (i.e.  $0 \leq \text{Position} < \text{Rotary Rollover Point}$ ). All other parameters function the same as they do with absolute indexes. An Absolute Index is a direct move to a specific position,



regardless of the starting point. A Rotary Plus Index moves to the specified position, but is forced in a positive direction. Similarly, a Rotary Minus Index moves to the specific position, but is forced in a negative direction.

Rotary Plus and Minus Indexes are usually used in rotary applications, therefore the rotary rollover feature on the User Units view in PowerTools Pro software must be enabled to use them.

1. In the following examples the term “D” = (absolute position specified) - (current position). If “D” is negative, motion in the negative direction is implied.
2. In the following examples the Rotary Rollover parameter on the Setup - Position view is set to 360.00°. This means that with each revolution of the motor (or rotary table), feedback will count up to 359.99°, then roll over to 0°.

### Indexes with Rotary Rollover Enabled

Incremental move distances can be outside of the rotary rollover range. See “Setting Up Parameters” on page 3 section for an explanation of Rotary Rollover.

**Example 1:** If the starting position is at 0° and 720° is the specified distance, an Incremental index would move 2 revolutions in the positive direction. At the completion of this index the motor position would be 0°.

Absolute indexes will take the shortest path to the specified position. Absolute index positions must be within the rotary rollover range.

**Example 2:** If the starting position is at 90° and 80° is the specified position, an Absolute index would travel 10° in the negative direction. At the completion of this index the motor position would be 80°.

**Example 3:** If the starting position is 45° and 315° is the specified position, an Absolute index would travel 90° in the negative direction because that is the shortest path between 45° and 315°.

Rotary Plus indexes will move to the specified position and are forced in a positive (or plus) direction. Rotary Plus index distances must be within the rotary rollover range.

**Example 4:** As in example 2 above, the starting position is at 90° and 80° is the specified position. A Rotary Plus index would travel 350° in the positive direction. At the completion of this index the motor position would be 80°.

**Example 5:** If the starting position is 10° and the specified position is 350°, a Rotary Plus index will travel 340° in the positive direction.

Rotary Minus indexes move to the specified position, but are forced to travel in the negative (or minus) direction. Rotary Minus index positions must be within the rotary rollover range.

**Example 6:** As in examples 2 and 4 above, the starting position is at 90° and 80° is the specified position. A Rotary Minus index would travel 10° in the negative direction. At the completion of this index the motor position would be 80°.

**Example 7:** If the starting position is 15° and the specified position is 270°, a Rotary Minus index would travel 105° in the negative direction.

## Index Parameters

### Distance/Position

The Distance/Position parameter specifies the distance the index will travel (incremental index), the absolute position the index will move to (absolute index), or the limit distance (registration indexes).

### Velocity

The Velocity parameter specifies the peak velocity used for the index. The velocity parameter is unsigned and must be greater than zero.

### Acceleration

The Acceleration parameter specifies the acceleration value to be used during the index.

### Deceleration

The Deceleration parameter specifies the deceleration value to be used during the index.

## Dwell Time

The Index Dwell Time parameter specifies the amount of time the system will wait after the index motion before the index is considered complete.

## Index Count

The Index Count parameter specifies how many times the index will repeat itself upon being initiated. There are three different parameters to choose from, Repeat Forever, Repeat Count, and Repeat while Input Function active.

## Registration Tab

Registration indexes are highly accurate indexes that travel until either a sensor or torque limit is reached, or until a limit distance is achieved. The user may choose to register to one of two sensors labeled "Registration Sensor 1" and "Registration Sensor 2" or to one of two torque levels labeled "Torque Level 1" and "Torque Level 2". All items on the registration tab are unavailable until the Index Type is changed to "Registration".

### Registration Sensor 1 option button

If this input function is assigned to an input in the Input Lines view, this sensor will be used for completing the simple registration move.

### Registration Sensor 2 option button

If this input function is assigned to an input in the Input Lines view, this sensor will be used for completing the simple registration move.

### Torque Level 1 option button

When selected the index will use a torque level as defined on the Torque view as a registration sensor.

---

## Note

The torque level parameter will not LIMIT the torque produced by the drive.

---

### Torque Level 2 option button

When chosen the index will use a torque level as defined on the Torque view as a registration sensor.

---

## Note

The torque level parameter will not LIMIT the torque produced by the drive.

---

### Calculated Offset option button

When selected the drive will calculate the offset based on the deceleration and velocity specified for the index.

### Calculated offset

This parameter gives the calculated distance that the motor will travel after the registration index recognizes a sensor or torque level registration input.

### Specified Offset option button

When chosen the drive will use an offset value as specified by the user.

### Specified Offset

This parameter is the distance that the motor will travel after the registration index recognizes a sensor or torque level registration input. This parameter may be changed by the user.

### Registration Window enable

This check box when selected enables the Registration Sensor valid Window. When active, only registration marks that occur inside the registration window are seen as valid.

### Registration Window Start

This parameter defines the start of the Registration Sensor Valid Window relative to the start position of this index. This is an unsigned value and is relative only to starting position of this index. Index direction does not affect this parameter. The Registration Window Start position (or distance) should be less than the Registration Window End position. If a registration sensor is seen outside of this window (not between the WindowStart and WindowEnd positions) then it will be ignored.

## Registration Window End

This parameter defines the end of the Registration Sensor Valid Window relative to start position of this index. This is an unsigned value and is relative only to starting position of this index. Index direction does not affect this parameter. The Registration Window End position (or distance) should be greater than the Registration Window Start position. If a registration sensor is seen outside of this window (not between the WindowStart and WindowEnd positions) then it will be ignored.

## Calculations Tab

This tab is used to display the specific motion parameters based on the distance, velocity, acceleration, and deceleration entered into the parameters above. Calculations are displayed as "Commanded" calculations and do not take into consideration any limitations that the drive and motor selection may introduce into the system.

### Start Position

This parameter is used when the index type is selected to be an Absolute index. Given this case PowerTools Pro uses the position entered as the starting position of the index in order to display calculations accurately.

### Index Distance

This parameter displays the calculated amount of distance that the index will travel throughout the entire motion.

### Acceleration Distance

This parameter displays the calculated amount of distance that the motor will travel while the index is accelerating. The Acceleration Distance is based completely on calculated motion and does not include any limitations that might be introduced by the drive, motor, and load variables.

### At Velocity Distance

This parameter displays the calculated amount of distance that the index will travel at the velocity specified in the velocity parameter. The At Velocity Distance is based completely on calculated motion and does not include any limitations that might be introduced by the drive, motor, and load variables.

### Deceleration Distance

This parameter displays the calculated amount of distance that the motor will travel while the index is decelerating. The deceleration distance is based completely on calculated time and does not include any limitations that might be introduced by the drive, motor, and load variables.

### Peak Velocity Attainable

This parameter stores the calculated peak velocity of the index motion. If the acceleration and deceleration parameters are set in a fashion that the maximum velocity is not attainable, the peak velocity could be lower than the velocity specified in the velocity parameter. The Peak Velocity Attainable is based completely on calculated motion and does not include any limitations that might be introduced by the drive, motor, and load variables.

### Index Time

This parameter stores the calculated time that the index will take to complete. This index time is based completely on calculated time and does not include any limitations that might be introduced by the drive, motor, and load variables.

### Acceleration Time

This parameter displays the calculated time that it will take the index to accelerate. The Acceleration Time is based completely on calculated time and does not include any limitations that might be introduced by the drive, motor, and load variables.

### At Velocity Time

This parameter displays the calculated time that the index will be at its specified velocity as entered in the velocity parameter. The At Velocity Time is based completely on calculated time and does not include any limitations that might be introduced by the drive, motor, and load variables.

### Deceleration Time

This parameter displays the calculated time that it will take the index to decelerate. The deceleration Tim is based completely on calculated time and does not include any limitations that might be introduced by the drive, motor, and load variables.

## How Chaining Works

Chaining is a way to combine two or more indexes into a single sequence. Any index can be chained to another index regardless of index type. By chaining multiple indexes together, the user is only required to perform a single index initiate to execute multiple indexes. Each index in the chain is performed exactly the same as if they were run individually.

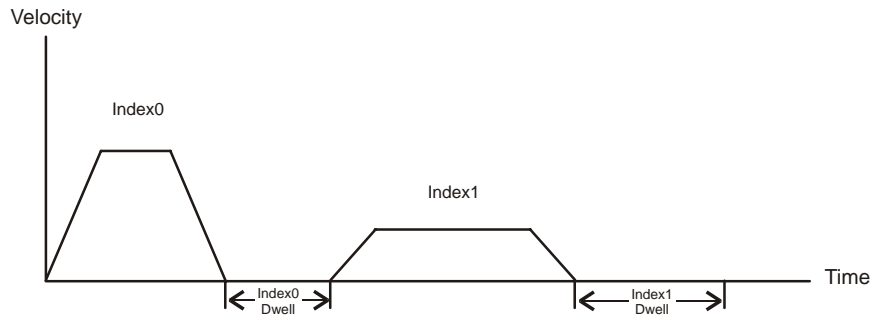


Figure 66: Chaining Example

In the above example, Index0 is chained to Index1. When the user activates the Index Initiate, Index0 starts and, upon completion of Index0 (after Index0 Dwell), Index 1 is automatically initiated. Index 1 could then be chained to a third index, or back to Index0 if desired.

All chaining configuration is done on the Chain tab on the Indexes screen. All index parameters are setup on the top portion of the screen. The chaining parameters are found on the Chain tab as shown below.

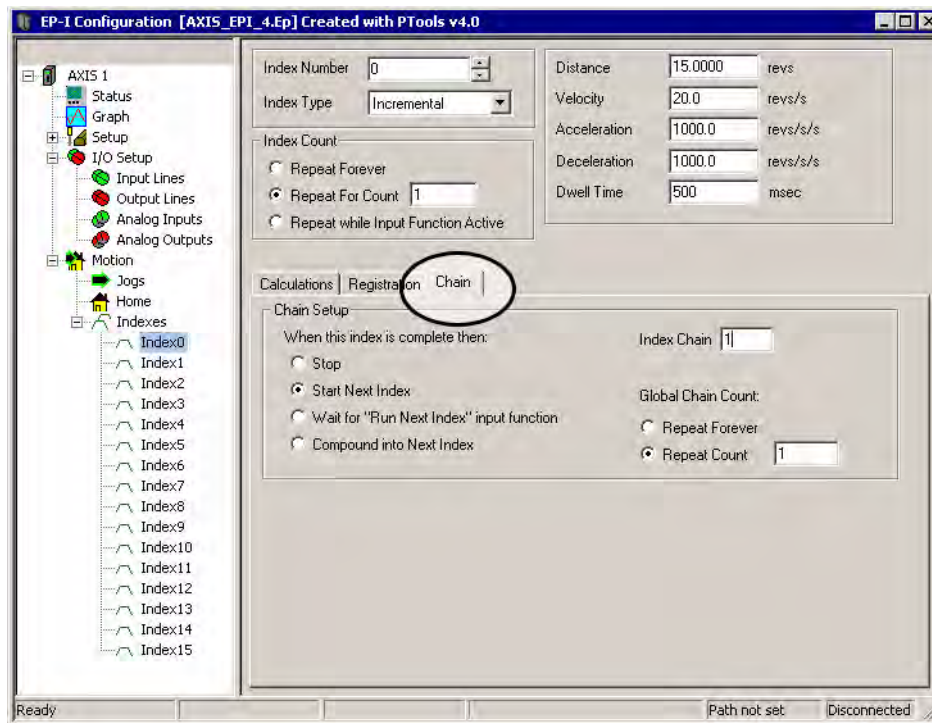


Figure 67: Index View – Chain Tab

## Chaining Parameters

Several parameters must be setup in order to create an index chain. These parameters are as follows:

### When this index is complete then:

This setting has four different options that define what will happen when the specific index is complete. The available options are Stop, Start Next Index, Wait for Run Next Index input function, or Compound into next Index. Stop is the default selection, so in a default configuration, no indexes are chained together.

## Stop

If “Stop” is selected, then the motor will come to a stop at the end of the index and the system will return to a Ready state. If Stop is selected, the Next Index parameter will be unavailable.

## Start Next Index

If “Start Next Index” is selected, then the specific index will be chained to the index number shown in the Index Chain text box. Therefore, at the end of the specified index (after Dwell is complete), the index shown in the Index Chain text box will start automatically.

## Wait for "Run Next Index" input function

If “Wait for Run Next Index input function” is selected, then the specific index will be chained to the index number shown in the Index Chain text box. At the end of the specified index (after Dwell is complete), the motor will stop and wait until the “Run Next Index” input function is activated. Once the “Run Next Index” input function is activated, then the index shown in the Index Chain text box will start immediately. This function can be used if hand-shaking is required between the device and a master controller. The device will wait for the master to activate the Run Next Index input to tell the device to continue.

## Compound into Next Index

If "Compound into next Index" is selected, then the specific index will maintain current index velocity until IndexDist is reached then the next index's accel ramp is used to change velocity.

## Index Chain

This parameter specifies what index the current index will be chained to. This parameter is only enabled when Start Next Index, Wait for "Run Next Index" input function, or Compound into next Index is selected. The default index to chain to is 0. If the user wishes to perform a chain of indexes multiple times, the Index in the Index Chain text box on the last index of the chain must be set to the first index of the chain. For example if Index0 is chained to Index1 which is chained to Index2, and the user wishes to run the chain multiple times. The Index in the Index Chain text box for Index2 must be set to 0 (Index 0).

## Global Chain Count

This setting defines how many times a chain of indexes will be repeated. The available options are Repeat Forever or Repeat Count #. The chain count only applies when the last index of the chain is chained to the first index of the chain. If the “When this index is complete then” setting is set to “Stop”, then the chain will not be repeated.

### Repeat Forever

If Repeat Forever is selected, then the chain will repeat itself infinitely. The only way to stop the chain is to activate the Stop input function.

### Repeat Count

If Repeat Count is selected, then the user must specify the number of times they wish to repeat the chain.

Only one Chain Count can be used at a time. The Global Chaining Count applies to all chains that are setup. If the user wants to run two different chains, then both chains use the same Chain Count.

# Index Input and Output Functions

The input and output functions related to indexes can be configured through PowerTools Pro software.

## Inputs

### Index Initiate

The Index Initiate Input function initiates the selected index. The selected index is specified using Index Select Input functions 0 through 3. If none of the index select functions are assigned, index #0 will be initiated.

No indexes can be initiated when other motion types are in progress (jogging or homing).

### Index Select Input 0 through 3

The Index Select Input functions are used to specify the index to be initiated with the Index Initiate input function. That is, the first line, Index Select 0, has the value of 1, the second, Index Select 1, a value of 2, the third, Index Select 2, a value of 4, the fourth, Index Select 3, a value of 8. The index number selected is the sum of the values of the active index select

functions. The table below shows this concept. The status of the four Index Select Input functions are combined together to form a 4 bit binary number.

Index Select #0 (value = 1)	Index Select #1 (value = 2)	Index Select #2 (value = 4)	Index Select #3 (value = 8)	Selected Index
Off	Off	Off	Off	0
On	Off	Off	Off	1
Off	On	Off	Off	2
On	On	Off	Off	3
Off	Off	On	Off	4
On	Off	On	Off	5
Off	On	On	Off	6
On	On	On	Off	7
Off	Off	Off	On	8
On	Off	Off	On	9
Off	On	Off	On	10
On	On	Off	On	11
Off	Off	On	On	12
On	Off	On	On	13
Off	On	On	On	14
On	On	On	On	15

With all four Index Select input functions inactive, Index number 0 will be initiated when the Index Initiate input function is activated. If you activate Index Select lines 0 and 1, Index number 3 ( $1 + 2 = 3$ ) will be initiated when the Index Initiate function goes active. If you activate all four Index Select lines simultaneously, the selected Index number is 15 ( $1 + 2 + 4 + 8 = 15$ ).

It is not necessary to assign all four Index Select input functions to input lines. Unassigned input functions are considered to be inactive. An application that only required four different indexes could assign Index Select 0 and 1 to input lines and leave Index 2 and 3 unassigned. The two input lines could then be used to select indexes 0, 1, 2 and 3.

### Registration Sensor 1

This input function is usually used with an external hardware sensor. It is used as the registration reference in a registration index. If the option button on the registration tab on the Index View is set to Registration Sensor 1, then the registration offset portion of the index will begin when this input function is activated. Two registration sensor input functions have been provided for applications requiring multiple sensors.

### Registration Sensor 2

This input function is usually used with an external hardware sensor. It is used as the registration reference in a registration index. If the option button on the registration tab on the Index View is set to Registration Sensor 2, then the registration offset portion of the index will begin when this input function is activated. Two registration sensor input functions have been provided for applications requiring multiple sensors.

### Run Next Index

This input function is used when chaining indexes together, and the user wants to wait for an input to continue the chain, instead of starting the Next Index instantly. If “When this index is complete then” is set to “Wait for run next index input function”, then the current index will complete itself, and wait until this input function is activated to begin the next index in the chain.

### Repeat Current Index

When the Repeat while Input Function active option button is selected on the Index view, an initiated index will continue to function until this input goes low.

## Outputs

### End Of Index

This output function is activated when any index is completed. This output function is deactivated when any Home, Jog or Index is initiated.

### End of Chaining Count

This output function is activated when the index chain has repeated the chain the number of times as specified in the Global Chain Count parameter. When the last index in the chain has completed the specified Chain Count times (after the Dwell), the End of Chaining Count will activate and remain on until the next index initiate.

### End of Index Motion

This output function activates when the motor ceases motion from a given index and becomes inactive when the next index is initiated. When indexes are chained together, the "End of Index Motion" output will turn on in between indexes. If chained indexes are configured such that there is no stop in motion then this output will still become active for 400usec in between indexes. When indexes are compounded together the "End of Index Motion" will not become active between indexes but will at the end of the compounding.

### Index In Position

This output function activates when the specified index motion command is completed. If a Stop is activated before the index has completed, the function will not be activated. This function is inactivated when the specified index command is executed, When indexes are chained together, the "End of Index Motion" output will turn on in between indexes.

## Examples

Below is a list of examples that use chaining and show timing diagrams for pertinent input and output functions based on index motion. The indexes for the examples are setup as follows:

#### Index0

Repeat for Count = 2

Dwell Time = 100 msec

When this index is complete then: Stop

#### Index1

Repeat for Count = 2

Dwell Time = 200 msec

When this index is complete then: Start next index

Index Chain = 2

Chain Count = 1

#### Index2

Repeat for Count = 1

Dwell = 300 msec

When this index is complete then: Stop

Chain Count = 1

#### Index3

Repeat for Count = 1

Dwell = 150 msec

When this index is complete then: Start next index

Next Index = 4

Chain Count = 2

#### Index4

Repeat for Count = 1

Dwell = 150 msec

When this index is complete then: Start next index

Next Index = 3

Chain Count = 2

#### Index5

Repeat for Count = 2

Dwell = 0 msec

When this index is complete then: Wait for run next index input function

Next Index = 6

Chain Count = 1

#### Index6

Repeat for Count = 1

Dwell = 150 msec

When this index is complete then: Stop  
Chain Count = 1

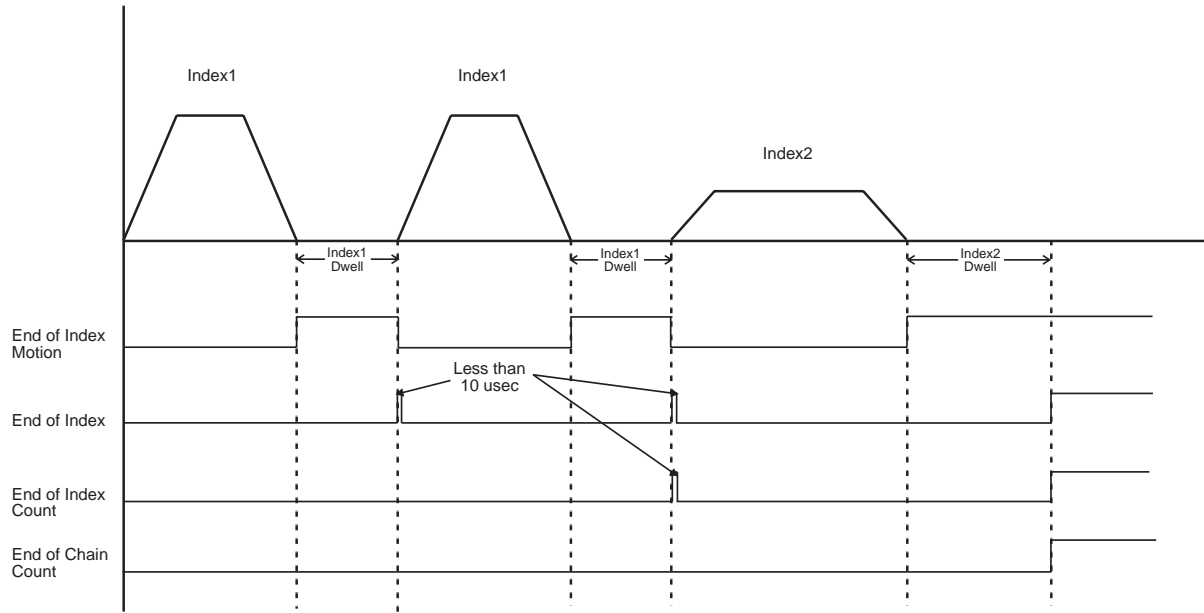


Figure 68: Example 1 – Index1 is chained to Index2 with a Chain Count of 1.

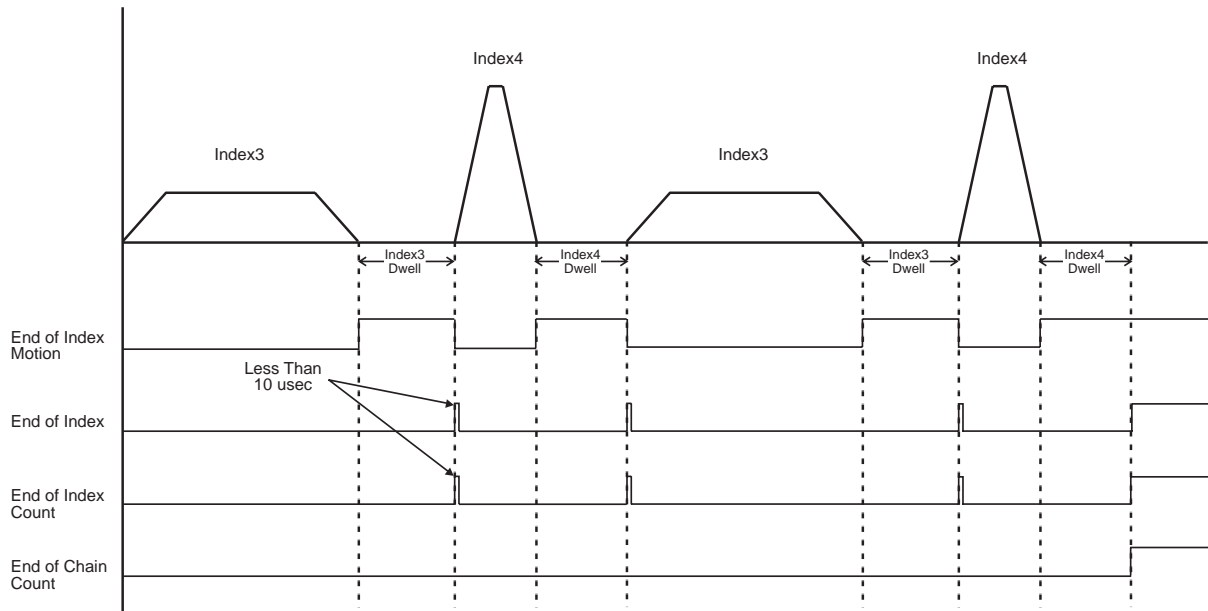


Figure 69: Example 2 – Index3 is chained to Index4 with a Chain Count of 2.



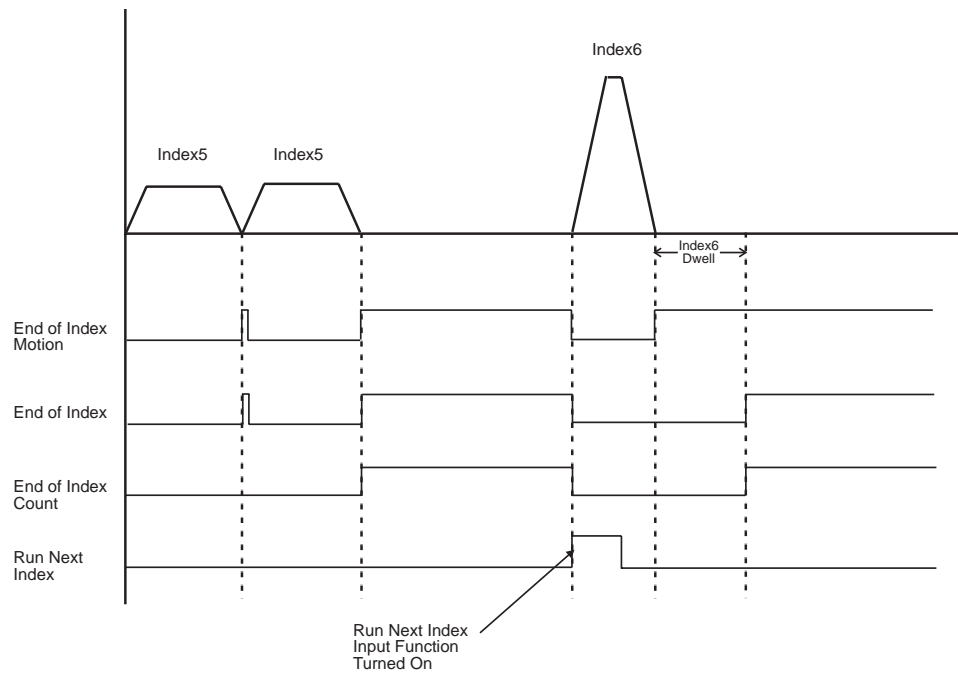


Figure 70: Example 3 – Index5 is chained to Index6 using the Wait for Run Next Index input function.

## How Alternate Mode Works

In addition to Jog, Index, and Home functions, the EP-I drive provides three basic modes of operation in Alternate Mode: Analog Velocity, Analog Torque, and Pulse Mode.

When in Alternate Mode the drive will ignore all Index, Home, or Jog initiate requests. If the drive is indexing, homing, or jogging when alternate mode is turned on, the drive will initiate a stop command and use the stop decel to ramp down to zero, then it will switch into alternate mode.

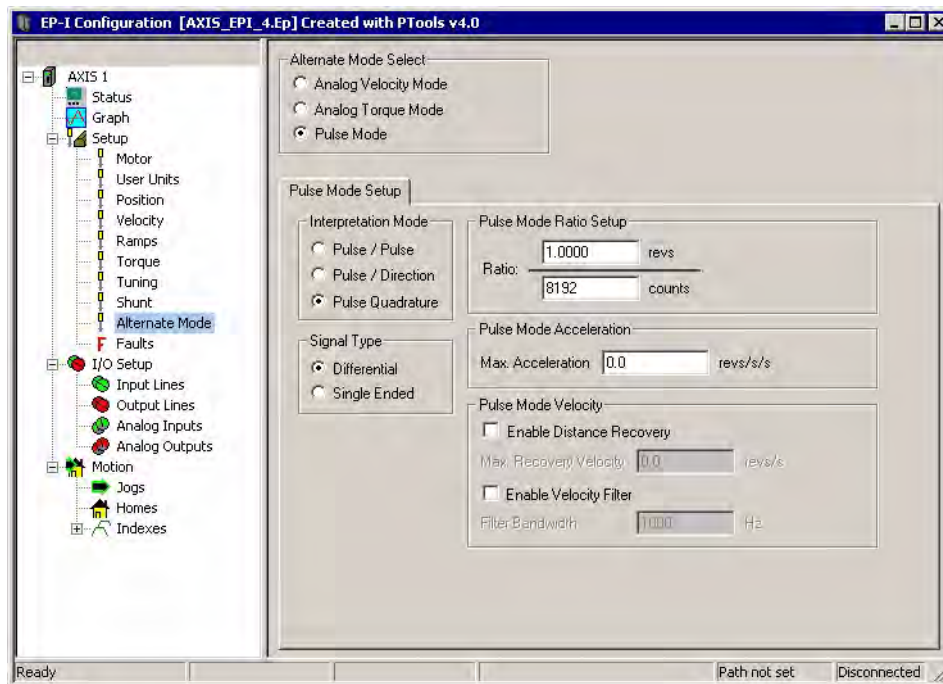


Figure 71: Alternate Mode Screen - Pulse Mode

## Alternate Mode Select

### Analog Velocity Mode

#### Analog Inputs

The Analog Inputs receives an analog voltage which is converted to the Velocity Command Analog parameter using the Full Scale Velocity, Analog Input Full Scale, and Analog Input Zero Offset parameters. The equation for this conversion is:

$$VCA = \frac{((AI - AZO) FSV)}{AFS}$$

Where:

VCA = Velocity Command Analog (RPM)

AI = Analog Input (volts)

AZO = Analog Input Zero Offset (volts)

FSV = Full Scale Velocity (RPM)

AFS = Analog Input Full Scale (volts)

The Velocity Command is always equal to the Velocity Command Analog in Analog Velocity mode. The Velocity Command is the command received by the velocity closed loop control.

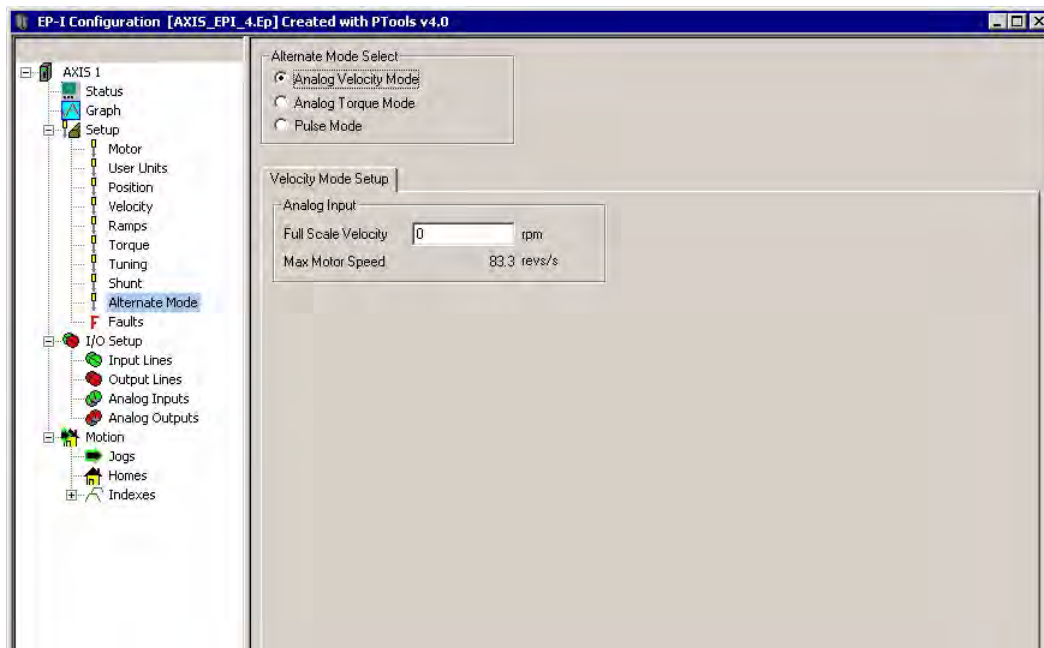


Figure 72: Alternate Mode - Analog Velocity Mode

### Analog Input Group

#### Full Scale Velocity

This parameter displays the maximum velocity attainable given the max analog value detailed in the Analog Full Scale parameter.

### Analog Torque Mode

In Torque mode both the position and velocity loops are disabled and only the torque loop is enabled.

---

#### Note

Velocity related faults and velocity related input and output functions are still enabled (including Stop and Travel Limits).

---

In Torque mode the drive receives an Analog Input which is scaled to the Analog Torque Command by the Full Scale Torque, Analog Input Full Scale, and Analog Input Zero Offset parameters. The equation is:

$$TC = \frac{((AI - AZO) FST)}{AFS}$$

Where:

TC = Torque Command

AI = Analog Input (volts)

AZO = Analog Input Zero Offset (volts)

FST = Full Scale Torque (%)

AFS = Analog Full Scale (volts)

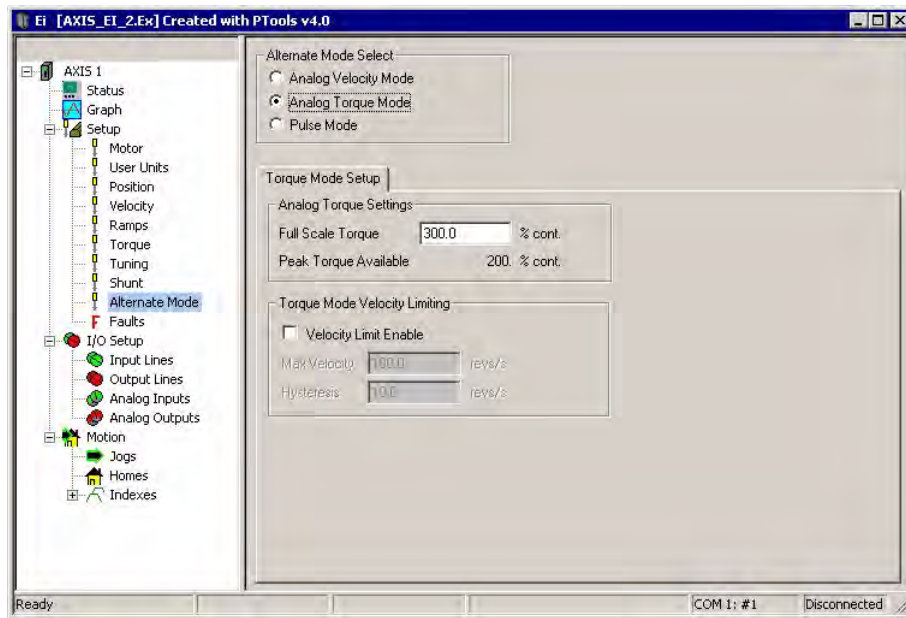


Figure 73: Alternate Mode - Analog Torque Mode

## Analog Torque Settings Group

### Full Scale Torque

This parameter allows the user to scale torque in the drive to the analog input. Full Scale Torque = 10 Vdc.

### Peak Torque Available

The Peak torque available parameter describes the peak torque available for the system, or the drive and motor combination based on the .ddf file.

## Torque Mode Velocity Limiting Group

### Velocity Limit Enable Check box

When this check box is selected, the Max Velocity and Hysteresis parameters are available in torque mode. This feature will stop the motor from "running away" when the torque is removed from the motor shaft.

### Max Velocity

When operating in Torque Mode, this parameter represents the maximum velocity attainable independent of the torque on the motor shaft.

### Hysteresis

When the Torque Velocity Limiting check box is selected, the drive will switch between Velocity Mode and Torque Mode depending on the speed of the motor. If the motor reaches the maximum velocity as specified by the Max Velocity parameter, the drive will switch into a constant Velocity Mode until the torque increases on the motor shaft bringing the motor speed down to the Hysteresis point. At this point the drive will switch back into Torque Mode until the Max Velocity point is reached again.

## Pulse Mode

In Pulse mode, the drive will receive pulses which are used to control the position and velocity of the motor.

There are three pulse interpretations associated with Pulse mode: Pulse/Pulse, Pulse/Direction and Pulse/Quadrature. These selections determine how the input pulses are interpreted by the drive.

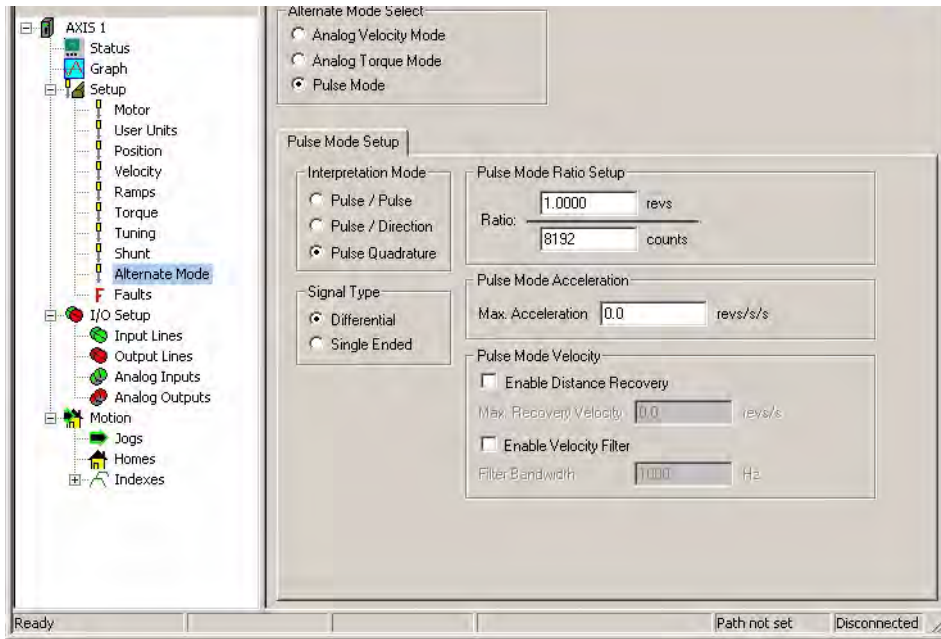


Figure 74: Alternate Mode - Pulse Mode

## Interpretation Mode Group

### Pulse/Pulse Interpretation

In Pulse/Pulse interpretation, pulses received on the A channel are interpreted as positive changes to the *Pulse Position Input*. Pulses received on the B channel are interpreted as negative changes to the *Pulse Position Input*.

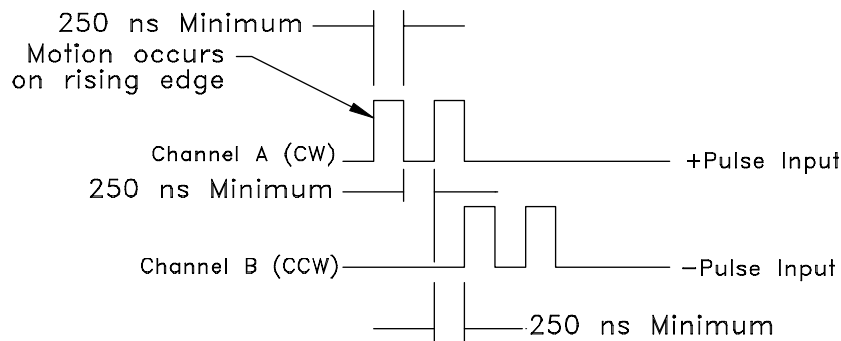


Figure 75: Pulse/Pulse Signals, Differential Inputs

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### Note

If a travel limit is encountered when in Pulse mode, the user must exit alternate mode and either jog or index off of the travel limit sensor before continuing.

---

### Pulse/Direction Interpretation

In Pulse/Direction interpretation, pulses are received on the A channel and the direction is received on the B channel. If the B is high, pulses received on the A are interpreted as positive changes to the *Pulse Position Input*. If the B is low, pulses received on the A are interpreted as negative changes to the *Pulse Position Input*.

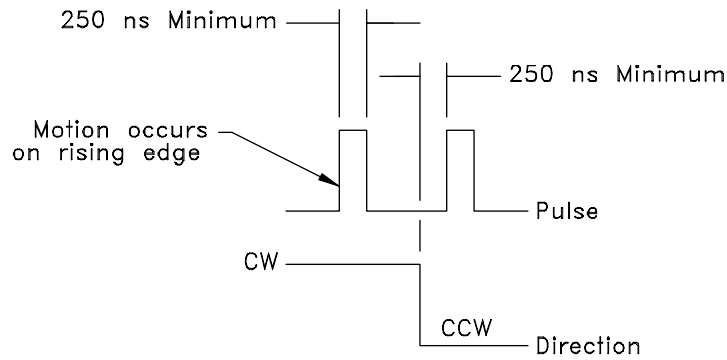


Figure 76: Pulse/Direction Signals, Differential Inputs

### Pulse/Quadrature Interpretation

In Pulse/Quadrature interpretation, a full quadrature encoder signal is used as the command. When B leads A encoder counts are received they are interpreted as positive changes to the *Pulse Position Input*. When A leads B encoder counts are received they are interpreted as negative changes to the *Pulse Position Input*. All edges of A and B are counted, therefore one revolution of a 2048 line encoder will produce an 8192 count change on the *Pulse Position Input*.

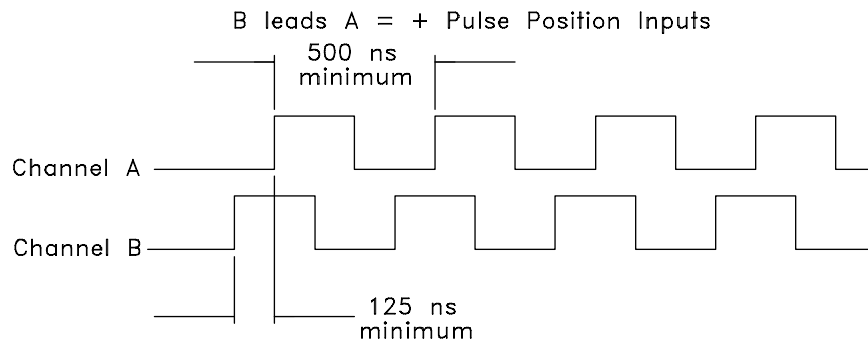


Figure 77: Pulse/Quadrature Signals, + Command

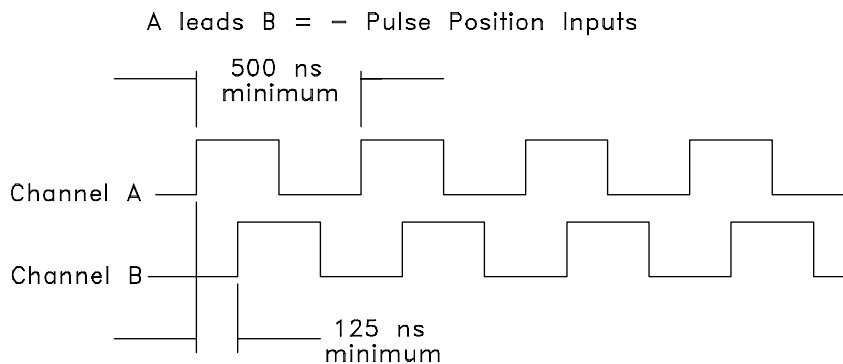


Figure 78: Pulse/Quadrature Signals, - Command

### Pulse Signal Type

The drive provides two types of pulse input circuits which allows you to choose the appropriate input type to match the device generating the position pulses. The selection is done by wiring to the desired input pins of the base drive command connector or the EP-I analog/sync output connector and then setting the Pulse Signal Type selection in the Alternate Mode view.

## Differential Source

The Differential setting (default) is perfect for most encoders or upstream drives. The differential input circuit is RS-422 compatible making it inherently noise immune while being able to accept pulse rates of up to 1.75 Mhz per channel.

## Single Ended Source

The Single Ended setting is a good match for any open collector driver that requires an external pull up resistor making it ideal for most stepper controllers, PLC stepper cards and PC computer parallel printer ports. The single ended inputs use high noise immunity circuitry and have internal pull-up resistors to the drive's 5 Volt logic supply so external pull-ups and biasing circuitry is not required.

The two hardware input circuits are included in the drive and are accessible through the drive command connector. When proper installation techniques are followed as shown below, the differential input setup will provide a more robust and noise immune system than a single ended input setup.

### Differential input is recommended under any of the following conditions:

- Pulse width < 2  $\mu$ s
- Pulse frequency > 250 kHz
- Pulse command cable length > 25 feet
- Noisy electrical environments

### Differential input circuit specifications:

Input frequency maximum: 1.75 Mhz  
 Input device: AM26C32  
 Input impedance: 12 Kohms each input  
 Maximum voltage applied to input pins (A, A/) or (B, B/):  
     Single Ended (referenced to 0V drive logic): +/-10 V  
     Differential (referenced to mating differential input): +/-10 V  
 Maximum common mode voltage: +/-7 V  
 Minimum differential voltage required: 200 mV  
 Input voltage hysteresis: 60 mV

### Epsilon EP-I Wiring Example:

STI-SNCI Terminal	Sync Connector Pin #	Pulse-Direction Signal	Pulse-Pulse Signal	Pulse Quadrature Signal
Sync Enc In "A"	1	Pulse	Pulse +	A
Sync Enc In "A/"	2	Pulse/	Pulse +/-	A/
Sync Enc In "B"	3	Direction	Pulse -	B
Sync Enc In "B/"	5	Direction/	Pulse -/	B/

### Single ended input circuit specifications:

#### Single ended input specifications:

- 1 MHz input frequency maximum
- Internal 330 ohm pull-up resistors to 5 Volt (non-isolated)
- 1.5 V low level
- 3.5 V high level
- Output driver requirements:
- 15 mA sinking (open collector)
- 5 V capacity

Signal common connected to Drive Logic 0V (Sync Encoder Common 0V)

- Pulse /: Commands motion on the falling edge (active edge).
- Direction: Positive (+) motion when high (inactive) and Negative (-) motion when low (active).
- Pulse CW /: Commands positive (+) motion on the falling edge (active edge) of a pulse.
- Pulse CCW /: Commands negative (-) motion on the falling edge (active edge) of a pulse.
- A and B: Encoder Quadrature signal interpretation. When B leads A Positive (+) motion commands will be generated, When A leads B, negative (-) motion commands will be generated.

Epsilon EP-I Wiring Example:

STI-SNCOA terminal	Analog/Sync Connector Pin #	Pulse-Direction Signal	Pulse-Pulse Signal	Pulse Quadrature Signal
4	4	Pulse /	Pulse CW /	A
12	12	Direction	Pulse CCW /	B

---

## Note

Actual motor rotation direction will depend on pulse ratio polarity and setting of the Positive Direction bit.

---

### Pulse Mode Parameters

The Pulse Input Posn parameter shows the total pulse count received by the drive since the last power-up.

The Pulse Input Posn, Position Command, Encoder Feedback and Position Feedback are initialized to zero on power-up. Only Position Feedback Encoder can be preloaded serially with a value after power-up.

### Pulse Mode Ratio Setup Group

#### Ratio

The Ratio parameter includes a numerator that represents motor revolutions, and a denominator that represents master pulses. The Pulse Mode Ratio Revolutions is allowed to be negative which reverses all Pulse mode motion.

### Pulse Mode Acceleration Group

#### Max. Acceleration

Sometimes when pulse mode is enabled, the Master will already be traveling at a velocity. By default the drive will attempt to ramp up to this velocity in one processor control loop. In most applications this very fast accel is not desirable. The maximum acceleration parameter displays a maximum ramp that the follower will use to ramp up to the specified pulse ratio. Once the follower is at the Master velocity, this accel parameter is disabled and the follower will follow pulse for pulse depending on the specified ratio.

### Pulse Mode Velocity Group

#### Enable Distance Recovery Check box

This check box when selected, activates the Distance Recovery feature of the drive. If a master is traveling at a velocity when pulse mode is initiated the follower will travel up to the specified ratio using an acceleration as specified by the user. If using the accel causes the follower to lose any pulses, these pulses will be saved into the Recovery Distance parameter and will be added onto the followers profile after it obtains the specified ratio.

#### Max Recovery Velocity

This parameter sets the maximum velocity that the motor may obtain as it corrects for pulses lost during the accel portion of pulse mode.

#### Enable Velocity Filter Check box

The Enable Velocity Filter check box is used to turn on or turn off the Input Pulse Velocity Filter. When the Enable check box is selected, the filter is active and the user may select the bandwidth desired to filter above. If clear, the filter is not used.

#### Filter Bandwidth

This parameter represents the bandwidth in hertz of the input pulses velocity filter. This filter must be enabled in order for it to function. The valid range of this parameter is 0 to 1200 hertz.

## Online Tab

This tab is only available when online with the drive.

### Velocity Group

#### Analog Command Velocity

When the drive is in Analog Velocity mode this parameter shows the current velocity commanded after the scaling of the Analog input function.

#### Velocity Command

This parameter is the velocity that the drive is commanding the motor to achieve. A properly tuned system should observe a velocity command that matches the velocity feedback.

#### Velocity Feedback

This parameter is the actual motor velocity feedback.

### Torque Group

#### Analog Torque Command

This parameter displays the torque that is being commanded via the analog input.

#### Torque Command

This parameter displays the actual torque being required from the drive.

#### Torque Cmd Limited

This displays the percent of torque being commanded to the motor. This value is the result of the Torque Command after being limited by the current foldback and the Torque Limit value (if active).

### Analog Input Group

#### Analog Input

This parameter displays the actual value of the analog input in volts.

### Distance Recovery Group

#### Recovery Distance

This parameter stores the number of counts that have been lost during the accel portion of pulse mode. These pulses may be used to recover any distance lost during accel by selecting the Enable Distance Recovery check box.

#### Pulse Input Posn

This parameter is the total number of actual pulses received on the pulse input hardware.

### Status Group

#### Alternate Mode Enabled

This virtual LED will be green when the Alternate Mode Enable Input is active.

#### Velocity Limiting Active

The virtual LED is green when velocity limiting is active.

## Alternate Mode Input and Output Functions

#### Alternate Mode Enable

This is a level sensitive function and may be enabled using Input assignments or through Modbus. Alternate Mode Enable allows the drive to run in either Pulse Mode, Analog Velocity Mode, or Analog Torque Mode.

#### Torque at Max Velocity

This output while in Torque mode, indicates that the motor is velocity limited.



## Drive Modifiers

This section describes functions that can modify the operation of the drive.

---

### Stop

The Stop input function, when activated, will cause motion to stop regardless of motor direction or the operating mode. The Stop Deceleration Ramp defines the rate of velocity change to zero speed.

Activating the Stop input function causes the drive to change to Velocity mode. Therefore, if you are operating in Torque mode, the drive must be tuned to the load to prevent instability when activating the Stop input function.

For example, if an application is operating in Torque mode at 3000 RPM, and the Stop input function is activated with a Stop Deceleration Ramp of 50 revs/s/s, the motor will decelerate to a stop in 1 second.

---

### **▲WARNING**

When the Stop input function is deactivated, the previous operating mode is restored within 400  $\mu$ s and the drive and motor will respond immediately with no ramping unless ramping is part of the selected mode.

---



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### +/- Travel Limits

The + and - Travel Limit input functions will stop motion in the direction indicated by the input function using the Travel Limit Deceleration rate. This feature is active in all modes. When an axis is stopped by a Travel Limit function, it will maintain position until it receives a command that moves it in the opposite direction of the active Travel Limit.

For example, the + Travel Limit will stop motion only if the motor is moving + but allows - motion to move off the limit switch. Conversely, the - Travel Limit will stop motion only if the motor is moving - but allows + motion to move off the limit switch.

If both input functions are active at the same time, no motion in either direction will be possible until at least one of the inputs is released.

When either + or - Travel Limit input function is activated, a fault will be logged into the Fault Log, and the drive will display an "L" on the LED diagnostics display on the front of the drive. Once the axis is driven off the limit switch, the fault will be cleared and the "L" will disappear.

If both Travel Limit input functions are activated simultaneously, the drive will respond as if the Stop input function has been activated and will use the Stop Deceleration ramp.

---

### Note

The function of the Travel Limits will be effected by the installation of the Function Module (FM) to the base drive. Please refer to the particular FM's reference manual for complete description.

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## Encoder Output Scaling

This feature allows you to change the drive encoder output resolution in increments of one line per revolution up to the density of the encoder in the motor. If the Encoder Output Scaling parameter is set to a value higher than the motor encoder density, the drive encoder output density will equal that of the motor encoder. This feature is enabled by checking the Encoder Output Scaling Enable check box in PowerTools Pro.

You can setup this feature from the Setup view in PowerTools Pro or using the MODBUS® parameters, Encoder Output Scaling and Encoder Output Scaling Enable.

## Current Foldback

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### Note

Current foldback is used to protect the motor and drive from overload. There is one level of current foldback: RMS Foldback.

RMS Foldback is displayed on the diagnostic display as a "C".

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## RMS Foldback

RMS foldback protects the motor from overheating. The RMS Foldback parameter models the thermal heating and cooling of the drive and motor based on the commanded current and the motor velocity. On power-up, the RMS Foldback level is zero and is continually updated. When the RMS Foldback level reaches 100 percent, current foldback is activated and the Foldback Active output function is active.

Each drive is designed to deliver up to 300 percent of the motor's continuous torque for no less than two seconds when running at 100 RPM or more. If only 150 percent of continuous torque is required, several seconds of operation before RMS foldback is typical.

During current foldback the Torque Command Actual will be limited to 80 percent continuous motor torque. Current foldback is cancelled when the RMS Foldback level falls below 70 percent. This could take several seconds or several minutes depending on the load.

The RMS Foldback value is dependent on both torque and velocity. At low speeds (<20 percent of maximum motor speed) the RMS Foldback will closely follow the Torque Command Actual. At high speeds (>50 percent of maximum motor speed) the RMS Foldback will read higher than the Torque Command Actual.

The time constant for RMS Foldback is 10 seconds. This means that if the load is 150 percent of continuous, it will take about 10 seconds to reach the foldback trip point.

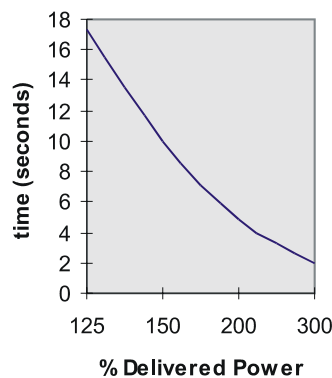


Figure 79: RMS Foldback Trip Point (this graph is accurate to  $\pm 5$  percent)

## Shunt Operation

### Epsilon EP-I

#### Shunt Operation

The EP204 and EP206 drives provide an internal shunt transistor. This transistor is active when the bus voltage reaches 405Vdc and shuts off when the bus voltage falls below 390Vdc.

#### External Shunt Operation

The DC bus is accessible for applications requiring additional regenerative power dissipation. Control Techniques offers an external shunt resistor kit for this use, model number: SM-Heatsink DBR-1. Optionally, the shunt output may be used to trigger a customer supplied shunt resistor of appropriate rating.

#### Shunt Control

An internal shunt control algorithm is used to prevent the external shunt resistor from overloading. It is necessary to provide the appropriate shunt resistor ratings in the PowerTools Pro software. Default values are in place for the Control Techniques shunt resistor kit.

## Brake Operation

Motor brake operation can be controlled by the Brake Release and Brake Control input functions. These input functions can be used together to control the state of the Brake output function. The table below shows the relationship between the Brake input and Brake output functions (see "Diagnostic Display").

**Note**

No motion should be commanded while the brake is engaged.

Brake Release Input		Off		On	
Brake Control Input		On	Off	On	Off
Drive Power Stage	Enabled	0	1	1	1
	Disabled	0	0	1	1

- \* (1) = Active output function  
(0) = Inactive output function

**Brake Release**

The Brake Release input function will release the brake under all conditions. When this input function is on, the Brake output function will be on (i.e., release brake). This input function overrides all other brake control, thus allowing the brake to be released while a fault is active or the power stage is disabled. See also Brake output function.

**Brake Control**

This input function, when active, will engage the brake unless overridden by the Brake Release input function. This input lets you externally engage the brake while allowing the drive to also control the brake during fault and disabled conditions.

**Brake**

The Brake output function is used to control the motor holding brake. If the Brake output function is off, the brake is mechanically engaged. When the brake is engaged, the diagnostic display on the front of the drive will display a “b”.

The drive outputs are limited to 150 mA capacity, therefore, a suppressed relay is required to control motor coil. Control Techniques offers a relay, model; BRM-1.

## Analog Inputs View

### Settings Group

**Bandwidth**

This parameter sets the low-pass filter cutoff frequency applied to the analog input. Signals exceeding this frequency will be filtered at a rate of 20 db per decade.

**Analog Full Scale**

This voltage sets the maximum value that the analog input will reach in normal operation. Valid range for this parameter is -10 to 10 volts.

**Analog Zero Offset**

This voltage corresponds to zero velocity in the motor and has a range from -10 to 10 volts.

## Analog Outputs

The drive has two 10 bit Analog Outputs which may be used for diagnostics, monitoring or control purposes. These outputs are referred to as Channel 1 and Channel 2. They can be accessed from the command connector.

Each Channel provides a programmable Analog Output Source.

Analog Output Source options are:

- Velocity Command
- Velocity Feedback
- Torque Command
- Torque Feedback
- Following Error

- Position Feedback

**Default Analog Output Source:**

- Channel 1 = Velocity Command
- Channel 2 = Velocity Command

Output	Source	Offset	Scale
1	Velocity Command	0	600 RPM/volt
2	Velocity Command	0	600 RPM/volt

Each channel includes a programmable Analog Output Offset and an Analog Output Scale. This feature allows you to “zoom in” to a desired range effectively increasing the resolution. The units for both of these parameters is dependent upon the Analog Output Source selection.

**Analog Output Offset units:**

- Velocity Command = RPM
- Velocity Feedback = RPM
- Torque Command = Percent of continuous torque
- Torque Feedback = Percent of continuous torque
- Position Feedback = Revs
- Following Error = Revs

**Analog Output Scale units:**

- Velocity Command = RPM/volt
- Velocity Feedback = RPM/volt
- Torque Command = Percent of continuous torque/volt
- Torque Feedback = Percent of continuous torque/volt
- Position Feedback = Revs/volts
- Following Error = Revs/volts

**Example:**

You could use the Analog Outputs to accurately measure velocity overshoot. For example, to measure a target velocity of 2000 RPM at a resolution of  $\pm 10V = \pm 200$  RPM do the following.

1. Selected Velocity Feedback for the Analog Output Source.
2. Set the Analog Output Offset to 2000 RPM.
3. Set the Analog Output Scale to 20 RPM/VOLT.

This will provide an active range from -10 to +10 Volts to represent 1800 to 2200 RPM. Therefore, the measured resolution has been increased.

## Digital Inputs and Outputs

External control capability is provided through the use of input and output functions. These functions may be assigned to any input or output line on the drive or the module. After they are assigned to lines, external controllers, such as a PLC or other motion controllers, may be used to affect or monitor the device’s operation.

Base drives are equipped with five optically isolated input lines (one dedicated to a Drive Enable function) and three optically isolated output lines. The FM-2 Module has an additional eight input and four output lines.

The base drive’s input and output lines can be accessed through the removable 10-pin I/O connector (J6), or through the 44-pin command connector (J5).

The drive’s input and output lines can be accessed through the 26-pin digital I/O connector (J3) on the front of the drive.

All inputs and outputs are configured as sourcing and are designed to operate from a +10 Vdc to +30 Vdc power source. The user is responsible for limiting the output current to less than 150 mA for each digital output.

## Input Function Active State

The active state of an input function can be programmed to be Active Off or Active On using PowerTools Pro. Making an input function “Active On” means that it will be active when 10 Vdc to 30 Vdc is applied to the input line it is assigned to, and is not active when no voltage is applied to the line. Making an input function “Active Off” means that it will be active when no voltage is applied to the input line and not active while 10 Vdc to 30 Vdc is being applied.

---

### Note

Input functions which initiate motion (Jog +, Jog -, Index Initiate and Home Initiate) cannot be set “Active Off”.

---

The user can also make an input function “Always Active”, which means that it is active regardless of whether or not it is assigned to an input line, and, if the function is assigned to an input line, it will be active whether or not voltage is applied to that line. This is useful for testing the drive operation before I/O wiring is complete.

### Input Lines Forced On and Forced Off

An input line can be forced to a level by using the “Forced On” and “Forced Off” check boxes. When you force an input line “On” or “Off”, all the functions assigned to that line will be affected.

---

### Note

The forced state of input and output lines are not saved to NVM and will be lost when the drive is powered down.

---

## Input Line Debounce Time

The user can program a “Debounce Time” which means the line will need to be “On” for at least the debounce time before it is recognized. This feature helps prevent false triggering in applications in noisy electrical environments.

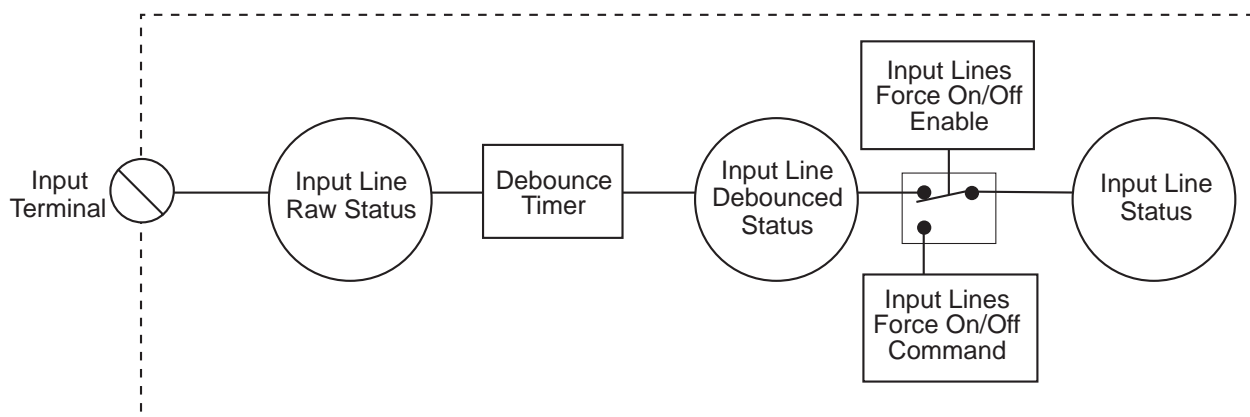


Figure 80: Input Line Diagram

If the Input Line attached to the home sensor is debounced, the actual rising edge of the Home Sensor is used to determine the Home Reference Position (the debounce time ensures a minimum pulse width).

### Output Lines Forced On and Forced Off

You can force an output line to a level by using the Forced On and Forced Off check boxes. When you force an output line “On” or “Off”, the output functions are not affected.

---

### Note

The forced state of input and output lines are not saved to NVM and will be lost when the drive is powered down.

---

## Output Line Active State

The default active state of an output line is “Active On”. This means that the output line will supply a voltage when the result of the logical Or of the output function(s) assigned to that output line is active.

Making an output line "Active Off" means that the line will be "Off" (not conducting) when the result of the logical Or of the output function(s) assigned to that output line is active, and will supply a voltage when the logical Or of the output function(s) is not active.

## Input Functions

### Alternate Mode Enable

This input function will enable the Alternate Mode features.

### Brake Control

This input function, when active, will engage the brake unless overridden by the Brake Release input function. This input function lets you externally engage the brake, while allowing the drive to also control the brake during fault and disabled conditions.

### Brake Release

This input function will release the brake under all conditions. If this input function is active, the brake output function is switched to active (i.e. release brake). This overrides all other brake control, thus allowing the brake to be released while a fault is active or the power stage is disabled.

### Define Home

This input function is used to set the absolute position to zero. On the rising edge of this input function the absolute position is set to zero and the Absolute Position Valid output function is activated.

### Home Initiate

This input function is used to initiate a home routine. The home is initiated on the rising edge of this input function. The drive will not initiate a home routine if there is an Index or Jog in progress or the stop input function is active. The Home Initiate Input function cannot be set "Active Off".

### Home Sensor

This input function defines the sensor used for homing. It is required if you are homing to a sensor or a sensor and marker. This function is edge sensitive. The sensor position is defined when the device senses the rising edge of the sensor.

### Index Initiate

This input function initiates the selected index. The index to be initiated is specified using the index select input functions 0 through 3. If none of the index select functions are assigned then index #0 will be initiated. This input function cannot be set "Active Off".

### Index Select 0 through 3

The Index Select Input functions are used to specify the index to be initiated with the Index Initiate input function. The format of the Index Select functions (0 through 3) is binary. That is, the first line, Index Select 0, has the value of 1, the second, Index Select 1, a value of 2, the third, Index Select 2, a value of 4, the fourth, Index Select 3, a value of 8. The index number selected is the sum of the values of the active index select functions. The table below shows this concept.

Index Select #0 (value = 1)	Index Select #1 (value = 2)	Index Select #2 (value = 4)	Index Select #3 (value = 8)	Selected Index
Off	Off	Off	Off	0
On	Off	Off	Off	1
Off	On	Off	Off	2
On	On	Off	Off	3
Off	Off	On	Off	4
On	Off	On	Off	5
Off	On	On	Off	6
On	On	On	Off	7
Off	Off	Off	On	8
On	Off	Off	On	9
Off	On	Off	On	10
On	On	Off	On	11

Index Select #0 (value = 1)	Index Select #1 (value = 2)	Index Select #2 (value = 4)	Index Select #3 (value = 8)	Selected Index
Off	Off	On	On	12
On	Off	On	On	13
Off	On	On	On	14
On	On	On	On	15

With all four Index Select lines assigned, but none of them active, Index number 0 will be initiated when the Index Initiate input function goes activated. If you activate Index Select lines 0 and 1, Index number 3 ( $1 + 2 = 3$ ) will be initiated when the Index Initiate function goes active. If you activate all four Index Select lines simultaneously, the selected Index number is 15 ( $1 + 2 + 4 + 8 = 15$ ).

### Jog +

This input function causes the drive to jog in the positive direction. It cannot be set "Active Off". This input function will have no affect if the device is already performing a home or an index, or if the stop input function is active or if the Travel Limit + Input function is active.

### Jog -

This input function causes the drive to jog in the negative direction. It cannot be set "Active Off". This input function will have no affect if the device is already performing a home or an index, or if the stop input function is active.

### Jog Fast

This input function is used in conjunction with the Jog+ and Jog- functions to specify the desired jog speed. When it is not active and Jog + or Jog - is activated, the drive will jog at the velocity specified by the Jog Velocity parameter. When it is active and Jog + or Jog - is activated, the drive will jog at the velocity specified by the Jog Fast Velocity parameter.

### Registration Sensor 1

This input function is usually used with an external hardware sensor. It is used as the registration reference in a registration index. If the option button on the registration tab on the Index View is set to Registration Sensor 1, then the registration offset portion of the index will begin when this input function is activated. Two registration sensor input functions have been provided for applications requiring multiple sensors.

### Registration Sensor 2

This input function is usually used with an external hardware sensor. It is used as the registration reference in a registration index. If the option button on the registration tab on the Index View is set to Registration Sensor 2, then the registration offset portion of the index will begin when this input function is activated. Two registration sensor input functions have been provided for applications requiring multiple sensors.

### Repeat Current Index

When the Repeat while Input Function active option button is selected on the Index View, an initiated index will continue to function until this input goes low.

### Reset

This input function is used to reset fault conditions and is logically OR'ed with the Reset/Setup button on the front of the drive's. A rising edge is required to reset faults.

### Run Next Index

This input function is used with index chaining. If the "When this index is complete then..." setting is set to "Wait for Run Next Index input function", then the current index will stop and wait until this input function is activated before starting the next index in the chain.

### Stop

The Stop input function uses the Stop Deceleration Ramp to decelerate the motor to zero velocity and hold position. If the Stop input function is activated when a Jog, Index or Home is in progress, it will be terminated. When this function is active, all Jog, Index and Home input functions will be ignored.

When it is deactivated, all level sensitive and active input functions (Jog +, Jog -, Jog Fast) will become operational. For example, if the Jog + input function is active when the Stop input function is deactivated, the Jog + motion will initiate using the Jog Acceleration parameter.

The decimal point on the base drive status/diagnostic display goes "Off" when the stop function is activated (or the drive is disabled).

### Torque Limit Enable

This input function, when active, causes the Torque Command to be limited to the value of the Torque Limit parameter.

### Travel Limit + and -

The + and - Travel Limit input functions will stop motion in the direction indicated by the input function name using the Travel Limit Deceleration rate. These inputs will function regardless of how the motion was initiated (i.e., index, jog or home).

When an axis is stopped by a Travel Limit function, it will maintain position until it receives a motion command (i.e., jog) that moves it in the opposite direction of the active Travel Limit.

For example, the Jog + input could be used to move off the Travel Limit -.

## Output Functions

### Absolute Position Valid

This output is activated when either the Define Home input function is activated or the End of Home output function is activated. This output is deactivated if the drive is rebooted, an encoder fault occurs, the device is powered down, or a home is reinitiated.

### At Velocity

This output function is active whenever the motor is at the peak commanded velocity of a home, jog or index. It activates when the acceleration ramp completes and deactivates when the deceleration ramp begins.

### Brake

The Brake output function must be used to control the motor holding brake. If the Brake output function is off, the brake is mechanically engaged. When the brake is engaged, the diagnostic display on the front of the drive will display a "b".

### Drive OK

This output function is active whenever no fault condition exists. Travel limits and the Drive Enable have no effect on this output function.

### End of Chaining Count

This output function will activate when the index chain count is complete or the index chain has repeated itself the specified number of times. This output function will remain active until another chain is started.

### End of Home

This output function is activated when a home cycle is completed successfully (Home Limit distance not hit). When this output function is activated, the Absolute Position Valid output function is activated. This output function is deactivated when any Index, Home or Jog is initiated.

### End of Index

This output function is activated when any index is completed. This output function is deactivated when any Home, Jog or Index is initiated.

### End of Index Count

This output function will activate when an index repeats itself the number of times specified in the index count parameter. It will remain active until the next index is initiated. If "Repeat Forever" is selected for the index count, this function will never activate.

### End of Index Motion

This output function will activate when the index motion stops (prior to dwell). It will remain active until another index is initiated or the next index in the chain begins. If two indexes are chained together without a dwell in between (dwell at default of 0 ms), then this output function will be active for 400  $\mu$ s.

### Fault

This output function is active whenever a drive fault condition exists.

### Foldback Active

This output function is active when the drive is limiting motor current. If the RMS Foldback value exceeds 100 percent of the continuous rating, the current foldback circuit will limit the current delivered to the motor to 80 percent of the continuous rating.



**Home Limit Distance Hit**

This output function indicates that no home reference was sensed during the move to the Home Limit Distance.

**In + and In - Motion**

This output function is activated whenever the velocity is greater than the In Motion Velocity parameter in the positive or negative direction. The default value for the In Motion Velocity parameter is 10 RPM. Hysteresis is used to avoid a high frequency toggling of this output function. This function is deactivated when the motor velocity slows to less than 1/2 of the In Motion Velocity parameter.

**Index in Position**

At the end of an index this output is activated when the position feedback is within a specified window of distance from the position command for a specific amount of time.

To implement this function the user must set up an "index in position" window and time (found in the Position view). After the index command is complete, the output will not become active until the position feedback is within the "index in position" window for the amount of time specified by "index in position" time.

**Over Temperature Current Limit Active (MDS Only)**

The Over Temperature Current Limit Active output will turn on when the measured heatsink temperature is above 70° C. This output will limit the drive module peak current available to 170% of continuous current. This limitation only happens in the MD-410, MD-420 and MD-434 drive modules. This output will stay active until the heatsink has had time to cool down to 60° C.

**Power Module System Ready (MDS Only)**

The System Ready output is active (high) when the power module has completed the powerup sequence properly. Once this signal is active the drive module can be enabled. The System Ready output remains high during normal system operation and turns low in case of system fault. If AC power is on and System Ready output is low, one of the following has occurred: Shunt fault, Over Temperature fault or High VAC Input.

**Power Stage Enabled**

This output is active when the drive or drive module is OK and enabled. It will go inactive when anything happens to disable the output power stage.

**Registration Limit Distance Hit**

This output function will activate if a registration index travels the full limit distance without seeing a registration sensor or torque level (depending on which was selected).

**Shunt Active**

This is a real time indicator of the internal shunt activity.

**Travel Limit + and -**

These output functions are active when the associated Travel Limit input functions are active.

**Torque at Max Velocity**

This output function is active only when the drive is in Analog Torque Mode. When "Torque Velocity Limiting" is enabled and the velocity feedback reaches the specified "Max Velocity" this output is activated and the motor velocity reaches a ceiling.

**Torque Level 1 and 2 Active**

This output is active if the Torque Command exceeds the specified Torque Level 1 value.

**Torque Limit Active**

This output is active if the Torque Command exceeds the specified Torque Limit value. (The Torque Command Actual is limited to the torque limit).

# How Communications Work

## Configuring Communication

Before attempting to upload or download a configuration file using PowerTools Pro, the software must be configured to the correct communication settings for the intended communication connection.

The communication connection may be selected in the Upload Drive Configuration, Download to Device IDx or the Change Path dialog boxes. From the **Device** menu, choose **Upload Drive**, **Download** or **Path Change** to open the dialog box or the toolbar buttons can also be used, see below.

## Uploading

Uploading is the process of reading information back from the drive to the PowerTools Pro configuration file views.

To upload information from a drive, click on the *Upload All* button, on the PowerTools Pro toolbar or from the **Device** menu, choose **Upload All** or **Upload Drive**. The Upload Drive Configuration dialog box will open, all communication connections are scanned and the results appear. In Figure 81, it shows that one device on COM 1 was found, an Epsilon Eb-205 drive. The Upload Drive Configuration dialog box contains the following information for every device found:



- Ip Address/COM
- Modbus Address ID
- Drive Type
- Module Type
- Communication Options
- Base/Drive FW Revision
- Module FW Revision
- Module Serial Number
- Drive Serial Number

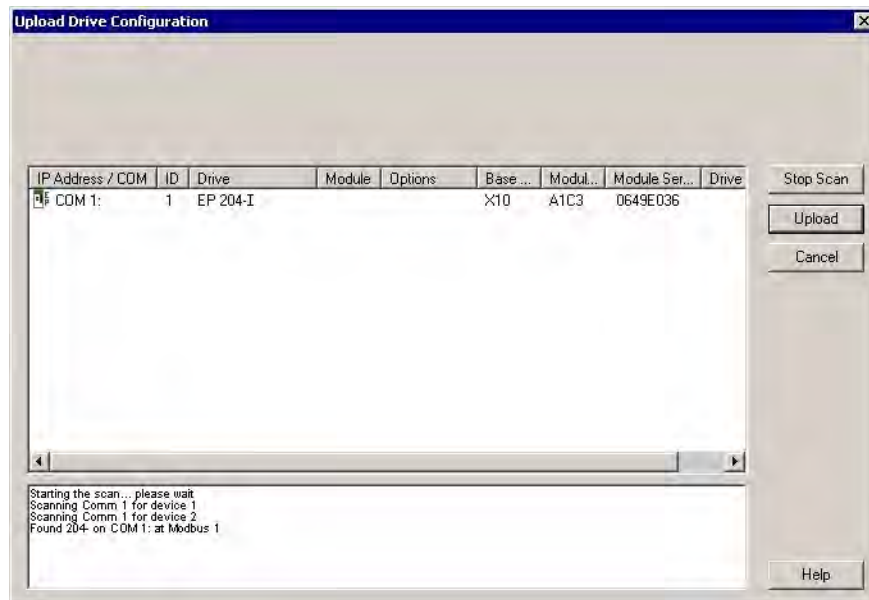


Figure 81: Upload Drive Configuration Dialog Box

Select the device to upload and click *Upload*.

## Downloading

Downloading is the process of sending the configuration created with PowerTools Pro from the PC to the device. Changes made in PowerTools Pro will not take effect until the information has been downloaded or the Update to RAM button has been clicked.

To download information to a device, click the *Download* button on the PowerTools Pro toolbar or from the **Device** menu, choose **Download**. The Download to Device IDx dialog box will open, all communication connections are scanned and the results appear. In Figure 82, one device on COM port 1 was found. The Upload Drive Configuration dialog box contains the following information for every device found:



- Ip Address/COM
- Modbus Address ID
- Drive Type
- Module Type
- Communication Options
- Base/Drive FW Revision
- Module FW Revision
- Module Serial Number
- Drive Serial Number

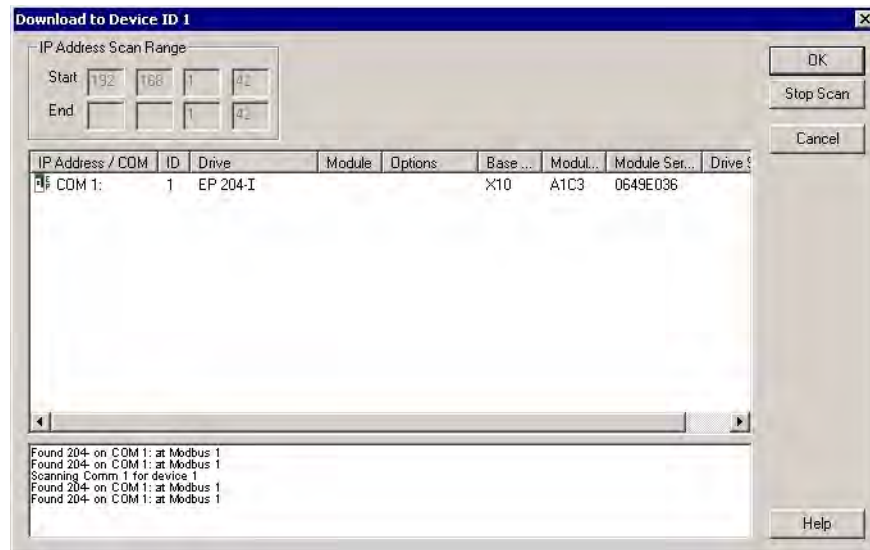


Figure 82: Download to Device ID 1 Dialog Box

Select the device to download to and click *OK*.

## Change Path Connection

This function allows the user to change the drive and Ip address/Com port used for download and upload. It is used when the user has already selected one Ip address/Com port and wishes to change to another.

The dialog box provides the user with communication information available on the Modbus and Ethernet network (if appropriate). This information contains:

- Ip Address/COM
- Modbus Address ID
- Drive Type
- Module Type
- Communication Options

- Base/Drive FW Revision
- Module FW Revision
- Module Serial Number
- Drive Serial Number

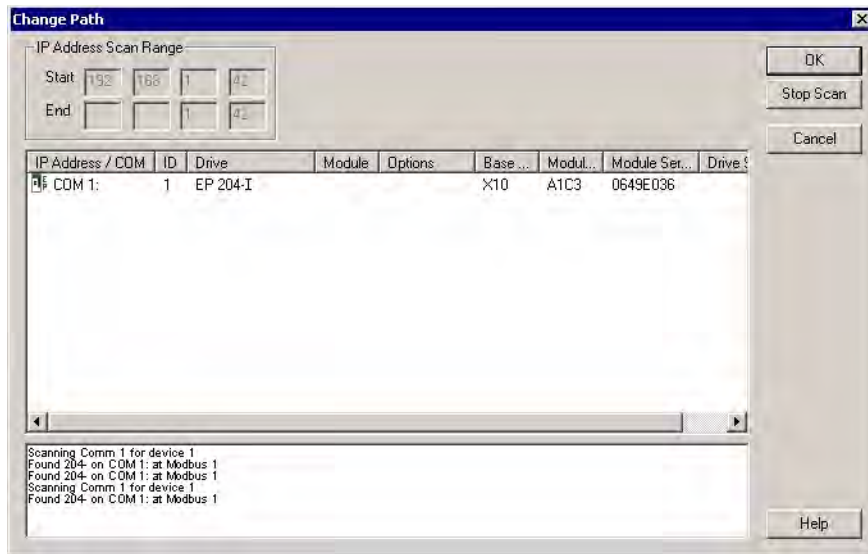


Figure 83: Change Path Dialog Box

Select the device in the list and then click *OK*. The communication connection path will then be displayed in the status bar at the bottom of PowerTools Pro window.

## Offline Setup

### Note

Generally, online setup is used when editing parameters in a device. Offline setup editing is usually only done when not connected to a device.

### Step 1: Opening an Offline Configuration Window

To open an offline Configuration Window, click the New button from the toolbar or select **New** from the **File** menu.

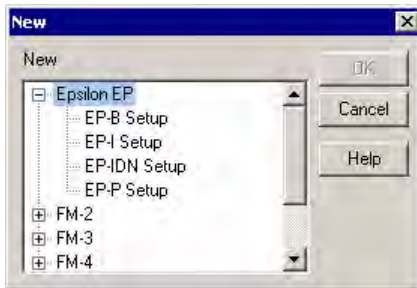


Figure 84: New Dialog Box

When the New dialog box appears, select the drive setup selection and click the *OK* button. A new Configuration Window will be displayed.

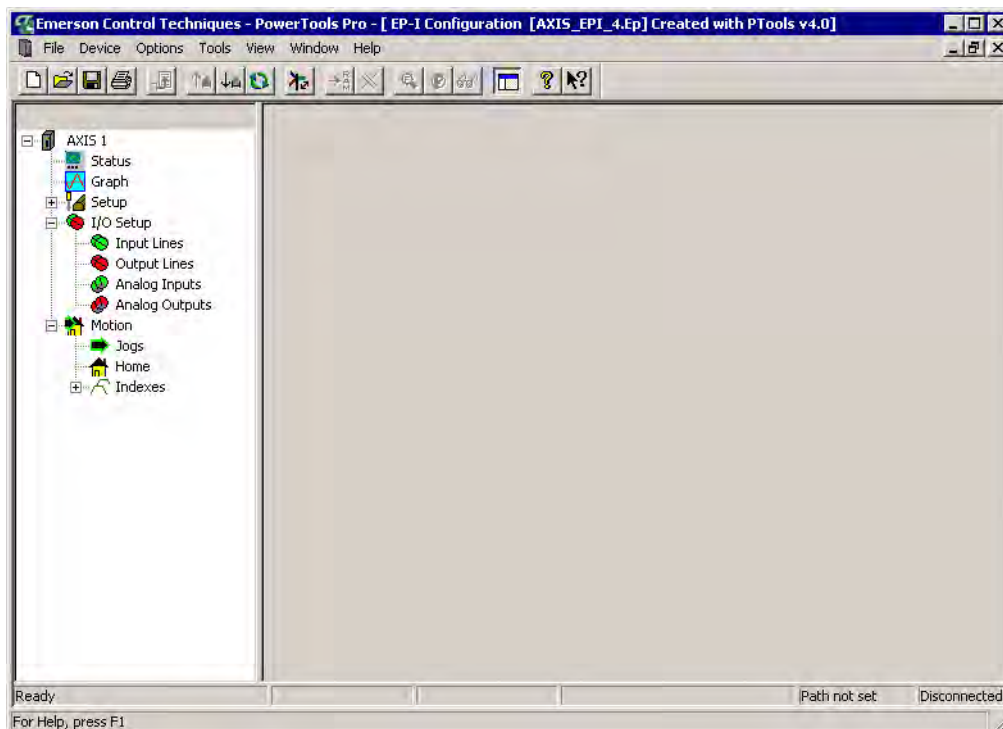


Figure 85: Offline Configuration Window

All drive setup parameters are accessible in the hierarchy tree of the offline configuration window.

You can now proceed to setup the drive parameters as desired.

### Step 2: Entering General Drive Setup Information

The Setup view contains system data such as drive type, motor type and axis name.

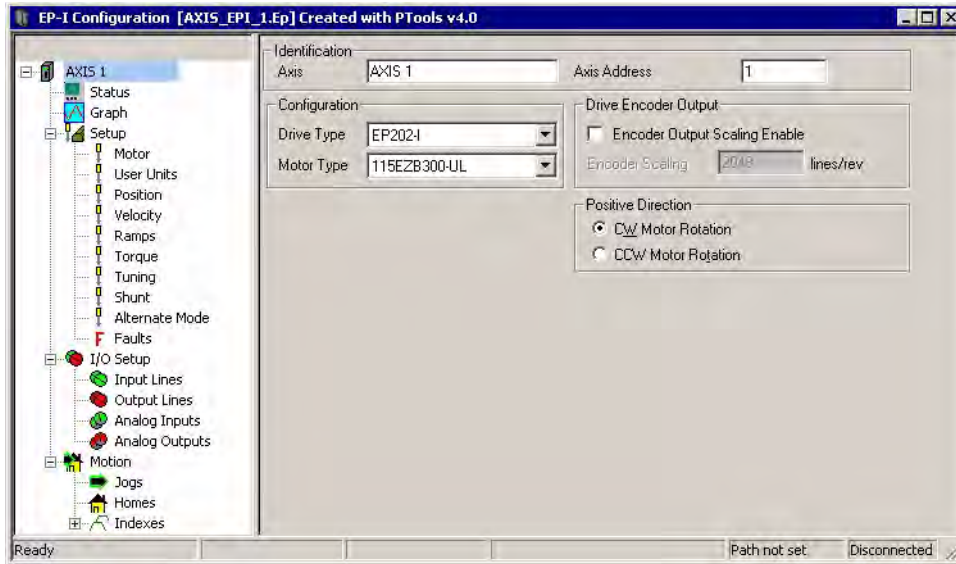


Figure 86: Setup View

Entering Identification Parameters:

1. Enter an axis identifying name for the drive you are setting up. You can use up to 24 alpha-numeric characters.
2. Enter the Axis Address to which you wish to download the setup information. Unless you have changed the Modbus address of your device, leave this parameter set to the default value of 1.

Entering Configuration Parameters:

1. Click the down arrow of the Drive Type list box, then select the drive model of the drive you are currently setting up.
2. Click the down arrow of the Motor Type list box, then select the motor connected to the drive you are setting up.

**CAUTION**

Selecting the wrong motor type can cause poor performance and may even damage the motor and/or drive.

Entering Positive Direction Selections:

Click which direction, clockwise (CW) or counterclockwise (CCW), to be considered as motion in the positive direction.

**Note**

CW and CCW rotation is determined by viewing the motor from the shaft end.

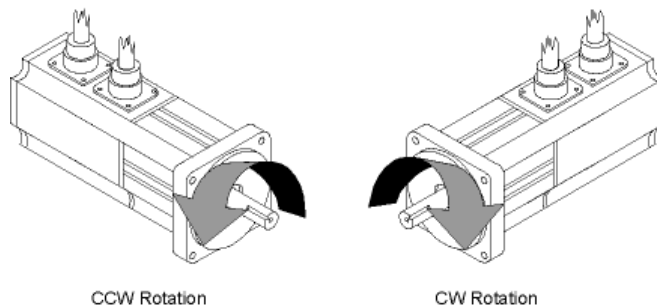


Figure 87: Motor Rotation

### Step 3: Assigning Inputs

Inputs are assigned in the Inputs view which is divided into two windows. The “Input Functions” window, on the left side, displays the input functions available, the function polarity and the always active state. The “Input Lines” window, on the right side, displays the drive enable input, four input lines, the debounce value and input function assignments.

#### Note

You cannot assign functions or Debounce the Drive Enable input line.

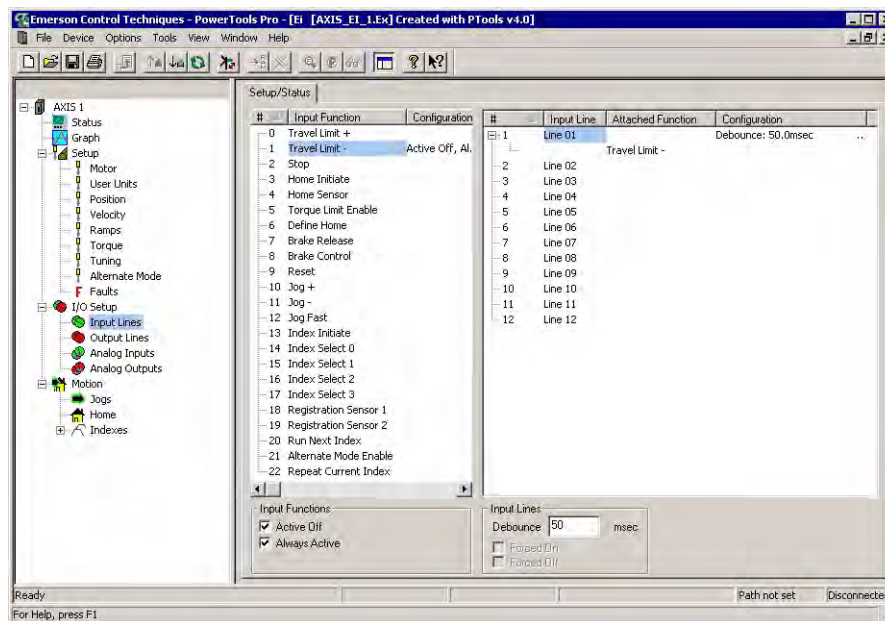


Figure 88: Inputs View

To assign an Input Function to an Input line:

1. Assign an input by highlighting an input function in the “Input Functions” window and drag the highlighted input function to the desired input line in the “Input Lines” window.
2. To unassign an input function from an input line, select the desired input function from the “Input Functions” window, then drag the highlighted input assignment back to the “Input Functions” window.

To make an Input Function “Active Off”:

1. Select the desired input function in the “Input Functions” window.
2. Click the “Active Off” check box. The Active State column in the “Input Functions” window will automatically update to the current setup.

To make an input function “Always Active”:

1. Select the desired input function in the “Input Functions” window.
2. Click the “Always Active” check box. The Active State column in the “Input Functions” window will automatically update to the current setup.

### Step 4: Assigning Outputs

Output functions are assigned in the Outputs view which is divided into two windows. The “Output Functions” window, on the left side, displays the output functions available. The “Output Lines” window, on the right side, displays the output lines, the line active state and the output function assignments.

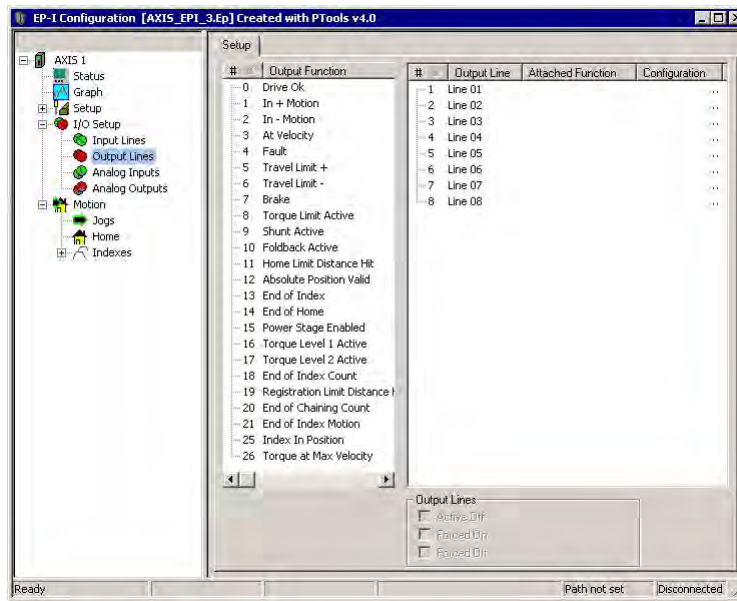


Figure 89: Outputs View

To assign an Output Function to an Output Line:

1. Assign an output by highlighting an output function in the "Output Function" window and drag the highlighted output function to the desired output in the "Output Line" window.

To unassign an Output Function from an Output Line:

1. To unassign an output function from an output line, select the desired output function from the "Output Line" window, then drag the highlighted output assignment back to the "Output Function" window.

To make an Output Function "Active Off":

1. Select the desired output line in the "Output Line" window.
2. Click the "Active Off" check box. The Configuration column in the "Output Line" window will automatically update to the current setup.

## Step 5: Setting Up Jogging

Jogging is controlled with the Jog +, Jog - and Jog Fast input functions. Jogging (like all motion types) is exclusive and will not be initiated when any other motion command is in progress.



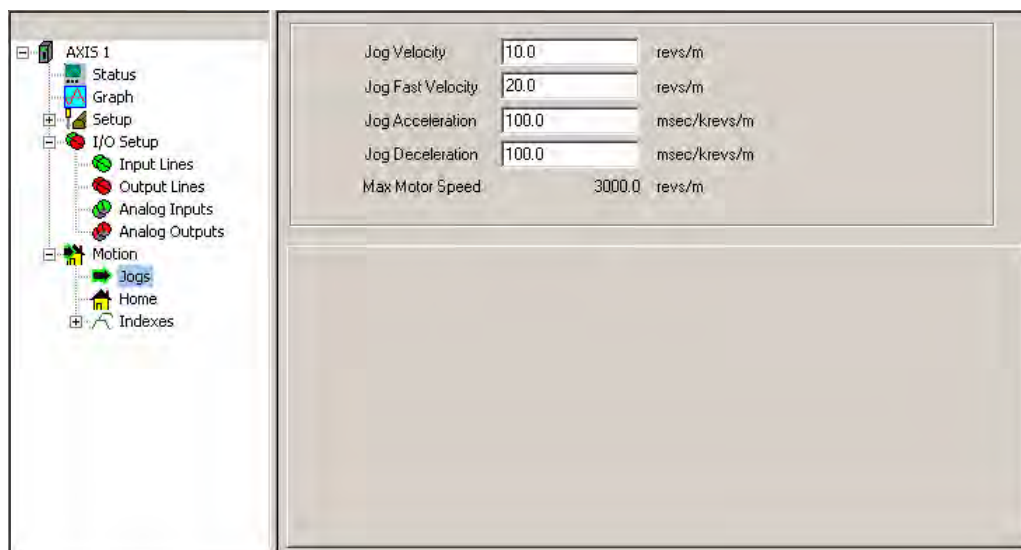


Figure 90: Jogging Parameter Set-up

Before initiating jogging motion, enter the jog related parameters as described below.

1. The Jog Velocity parameter specifies the velocity used for jogging when the Jog Fast input function is not active.
2. The Jog Fast Velocity parameter specifies the velocity used for jogging when the Jog Fast input function is active.
3. The Acceleration parameter specifies the acceleration value to be used during jogging.
4. The Deceleration parameter specifies the deceleration value to be used during jogging.

## Step 6: Setting Up the Home Routine

Many applications require that the axis be aligned with some part of the machine before indexes are initiated. The device has a powerful home routine for accomplishing this task. The parameters used by the home are described below.

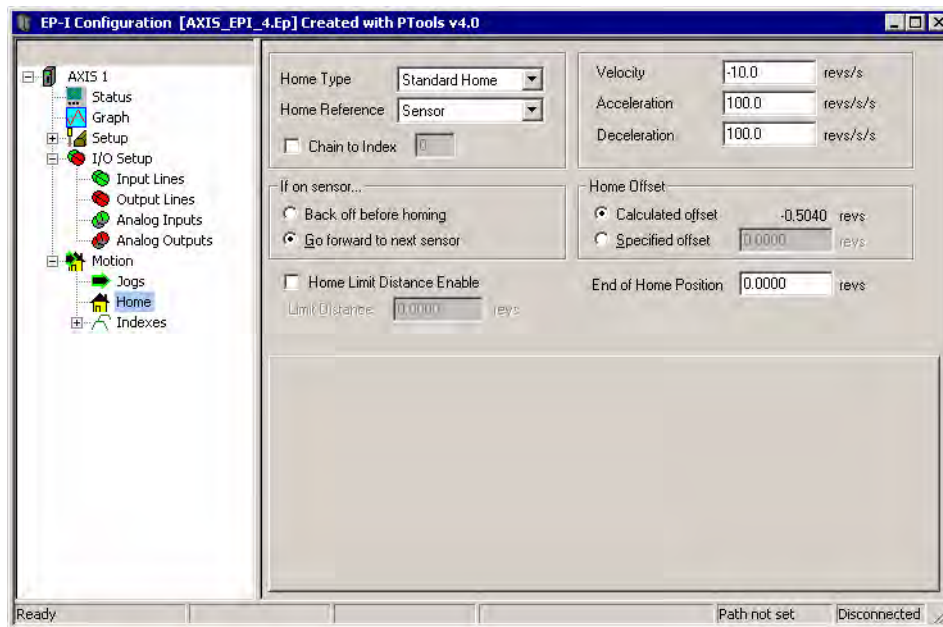


Figure 91: Home Routine Parameter

1. The Home Type parameter determines the type of home routine that the device will execute, Standard Home or One Side Home.

1. The Home Reference parameter determines how the home reference position is established. The parameter can have one of three different values: 'Sensor', 'Marker', 'Sensor and Marker'.
  - When the Home Reference is 'Sensor' the going active edge of the 'Home Sensor' input function is used to establish the reference position.
  - When the Home Reference is 'Marker' the rising edge of the motor encoder's marker channel is used to establish the reference position.
  - When the Home Reference is 'Sensor and Marker' the reference position is established using the first marker rising edge after the Home Sensor input function goes active.
2. The Velocity parameter specifies the velocity used for homing. Use a positive value to search for home in the positive direction and a negative value to search for home in the negative direction.
3. The Acceleration parameter specifies the acceleration value to be used during the home.
4. The Deceleration parameter specifies the deceleration value to be used during the home.
5. The Home Offset parameter designates the location of the home position in the machine coordinate system relative to the home reference. During the homing routine, after the home reference is detected, the device moves the motor to the home offset position. This may be a calculated value or a specified value. A calculated offset is the distance required to decelerate to a stop from the home velocity.
6. After the motor reaches the home offset position, the End of Home Position value is put into the command and feedback positions.
7. The Home Limit Distance check box enables the Home Limit Distance parameter. If this flag is not set, there is no limit to the distance the drive will travel during the home routine.
8. The Home Limit Distance parameter places an upper limit on the distance the motor will travel during the home. In situations where the reference position indicator (sensor or marker) is not seen, this parameter limits the total distance the motor will move.
9. Select either the Back off before homing or Go forward to next sensor option button in the "If On Sensor..." group. This determines the operation of the system if the Home Sensor input function is "On" when the home is initiated.

### Step 7: Setting Up Indexes

The device supports 16 indexes. They are configured in the Index view as described below.

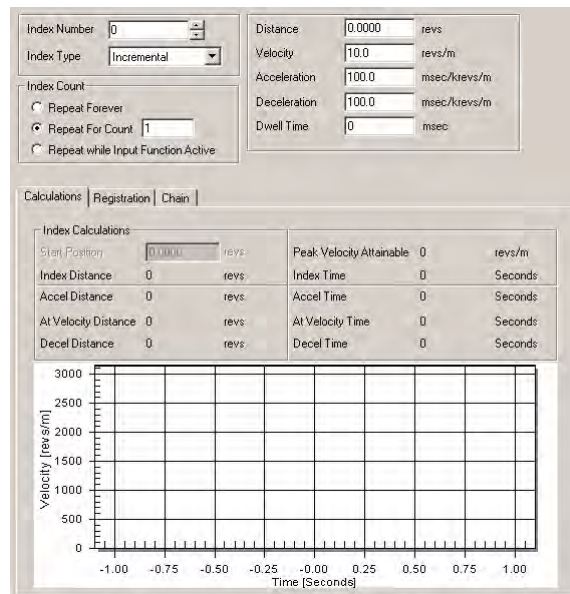


Figure 92: Index View Setup

1. Use the scroll wheels to select the Index Number you want to modify (0 to 15) or click the on the index number in the hierarchy view.
2. Select the index type. Absolute indexes travel to specific absolute positions. Incremental indexes move the axis a specific distance from its current position.
3. The Distance/Position parameter specifies the distance the index will travel (incremental index) or the absolute position the index will move to (absolute index).
4. The Velocity parameter specifies the velocity used for the index. The velocity parameter can not be negative.
5. The Acceleration parameter specifies the acceleration value to be used during the index.
6. The Deceleration parameter specifies the deceleration value to be used during the index.

## Online Setup

These steps assume you have already created a configuration file. If you have already downloaded the configuration file, go to Step 3. If you have not yet created the configuration file, go to Offline Setup Step 1. Do Steps 1 through 7 in the previous section, “Offline Setup”, before establishing communications.

---

### Note

Generally, online setup is used when editing parameters in a device. Offline setup editing is usually only done when not connected to a device.

---

### Step 1: Establishing Communications with Drive

Now that the basic device setup parameters are entered, it is time to establish communications with the device and download the configuration data. Before proceeding, be sure to connect the serial communication cable between your PC and the device.

When attempting to download a configuration using PowerTools Pro, the software may need to be configured to the correct communication settings for the intended connection.

To configure the preferences, select the Options|Preferences|Ptools Operations from the menu bar then select the Communications tab see Figure 93. This dialog box allows the user to configure which communication connections are scanned when performing any communication operations. Default is all ports are scanned.

The serial communication baud rate can be changed, the drive baud rate and PowerTools Pro baud rate must match. Default drive baud rate = 19200. PowerTools Pro will not check to see if any devices with node addresses higher than the number entered are available on the network. The default number is 4 with a maximum number of 32 node addresses.

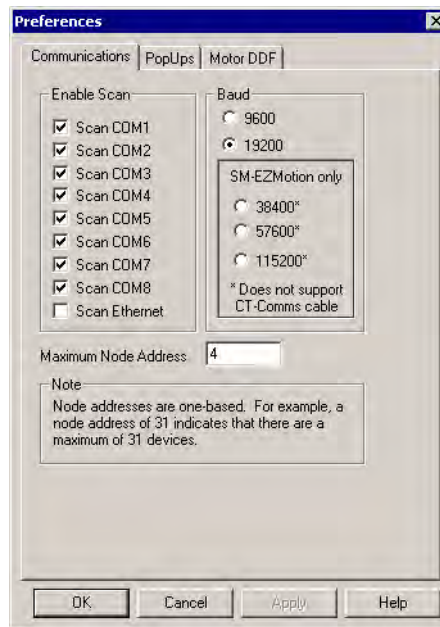


Figure 93: Communications Setup Screen

---

### Note

After communications are established the baud rate can be changed by selecting from the **Device** menu, choose **Change Baud Rate**.

---

### Step 2: Downloading the Configuration File

When you are ready to download the information in the current Configuration Window, go to the Setup view and enter the address of the device you wish to download to in the “Axis Address” text box.

Click the *Download* button in the toolbar or from the **Device** menu, **Download**.

PowerTools Pro will establish communications and transfer all the information in the current Configuration Window to the device you select.

---

### Note

Downloading will automatically clear an Invalid Configuration fault (“U” fault).

---

### Step 3: Opening an Online Configuration Window

If you are not already online with the device, use this section to upload a configuration for online editing.

To open an online Configuration Window, click the Upload button on the toolbar. PowerTools Pro will display the Change Path dialog box while it scans your PC’s ports for any compatible devices. Next, select the device you wish to upload into a Configuration window.

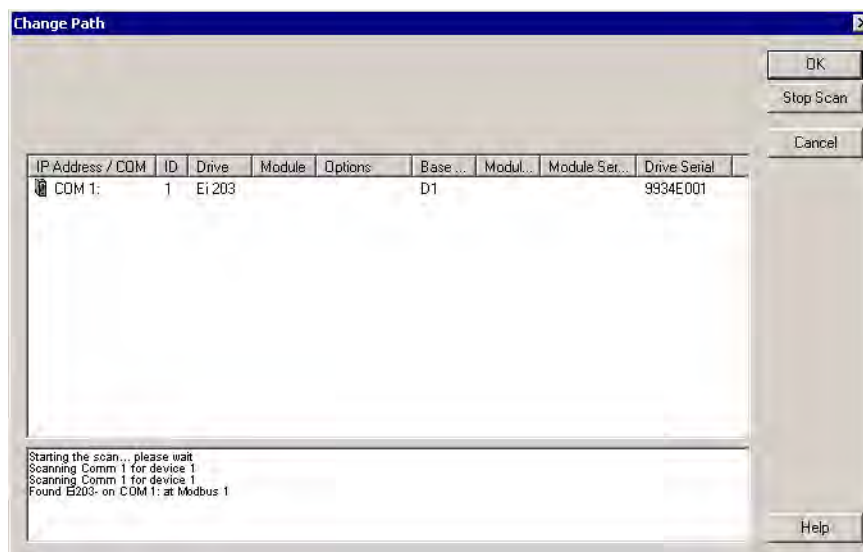


Figure 94: Upload Drive Configuration Dialog Box

## Step 5: Operation Verification

After downloading a configuration file to the device the user may want to verify the operation of the system using the checklist below.

1. I/O powered and Logic powered if applicable
2. Connections installed
3. Enable the drive
4. Verify “R” on the drive status/diagnostic display
5. Jog the axis with the Jog Control Panel on the Jog view or Jog +/-Jog - input functions
6. Initiate a Home
7. Initiate an Index

## Step 6: Saving the Configuration File

To save the drive setup information, select Save from the **File** menu. Follow the dialog box instructions.

## Step 7: Printing the Configuration File

To generate a printed copy of all the data in the drive configuration, select Print from the **File** menu. If you print while online, the print-out will include several pages of useful online diagnostic information.

## Step 8: Disconnecting Communications

After you successfully download to the drive, you may want to disconnect the serial communications link between the drive and your PC to clear the serial port or to access some PowerTools Pro options only available when offline.

To disconnect serial communications, click the *Disconnect* button on the toolbar (or select the Disconnect command from the **Device** menu).



# Tuning Procedures

The drive uses closed loop controllers to control the position and velocity Travel Limit of the attached motor. These position and velocity controllers and the associated tuning parameters are in effect when the drive is in velocity or pulse mode and have no effect when the drive is in Torque mode.

Many closed loop controllers require tuning using individual user-specified proportional, integral and derivative (PID) gains which require skilled “tweaking” to optimize. The combination of these gains along with the drive gain, motor gain, and motor inertia, define the system bandwidth. The overall system bandwidth is usually unknown at the end of the tweaking process. The drive closes the control loops for the user using a state-space pole placement technique. Using this method, the drive’s position control can be simply and accurately tuned. The overall system’s bandwidth can be defined by a single user-specified value (Response).

The drive’s default settings are designed to work in applications with up to a 10:1 load to motor inertia mismatch. Most applications can operate with this default setting.

Some applications may have performance requirements which are not attainable with the factory settings. For these applications a set of measurable parameters can be specified which will set up the internal control functions to optimize the drive performance. The parameters include Inertia Ratio, Friction, Response and Line Voltage. All the values needed for optimization are “real world” values that can be determined by calculation or some method of dynamic measurement.

## PID vs. State-Space

The power of the state-space control algorithm is that there is no guessing and no “fine tuning” as needed with PID methods. PID methods work well in controlled situations but tend to be difficult to setup in applications where all the effects of the system are not compensated for in the PID loop. The results are that the system response is compromised to avoid instability.

The drive state-space control algorithm uses a number of internally calculated gains that represent the wide variety of effects present in a servo system. This method gives a more accurate representation of the system and maximizes the performance by minimizing the compromises.

You need only to setup the system and enter three parameters to describe the load and the application needs. Once the entries are made the tuning is complete - no guessing and no “tweaking”. The drive uses these entries plus motor and amplifier information to setup the internal digital gain values. These values are used in the control loops to accurately set up a stable, repeatable and highly responsive system.

## Tuning Procedure

Once the initial setup has been completed, you can run the system to determine if the level of tuning is adequate for the application. A drive can be tuned basically to four levels.

- No Tuning
- Basic Level
- Intermediate Level
- Fully Optimized Level

Each level is slightly more involved than the previous one requiring you to enter more information. If your system needs optimization, we recommend that you start with the Basic Level, then determine if further tuning is needed based on axis performance.

The setup procedures explained here assume that you are using PowerTools Pro software or an FM-P.

## Initial Settings

Set the drive tuning parameters as follows:

- Inertia Ratio = 0
- Friction = 0
- Response = 50
- High Performance Gains = Enabled
- Feedforwards = Disabled

## Tuning steps

If your Inertia Ratio is greater than 10 times the motor inertia, go directly to the Intermediate Level tuning.

### No Tuning

No tuning will be required in most applications where the load inertia is 10 times the motor inertia or less.

### Basic Level

Adjust Response to obtain the best performance.

### Intermediate Level

1. Calculate or estimate the load inertia. It is always better to estimate low.
2. Disable the drive.
3. Enter the inertia value calculated into the Inertia Ratio parameter.
4. Set the Line Voltage to the applied voltage (default is 230 Vac).
5. Leave all other tuning parameters at the initial values.
6. Enable the drive and run the system.
7. Adjust Response to obtain the best performance.

### Fully Optimized Level

1. Determine the actual system parameters.
2. Disable the drive.
3. Enter the parameters.
4. Line Voltage set to the applied voltage (default is 230 Vac).
5. Enable the drive and run the system.
6. Adjust Response to obtain the best performance.

## General Tuning Hints

### General Tuning Procedure:

1. Calculate inertia of the system

The inertia of the system up to the motor shaft should be calculated using CT-Size software or some other inertia calculating software. Under perfect mechanical conditions, entering this number into the “Inertia” parameter will produce a well-matched system tuning. Because most systems include mechanics that are less than ideal, a number less than the inertia parameter will need to be used to avoid bandwidth issues or “buzzing” of the motor.



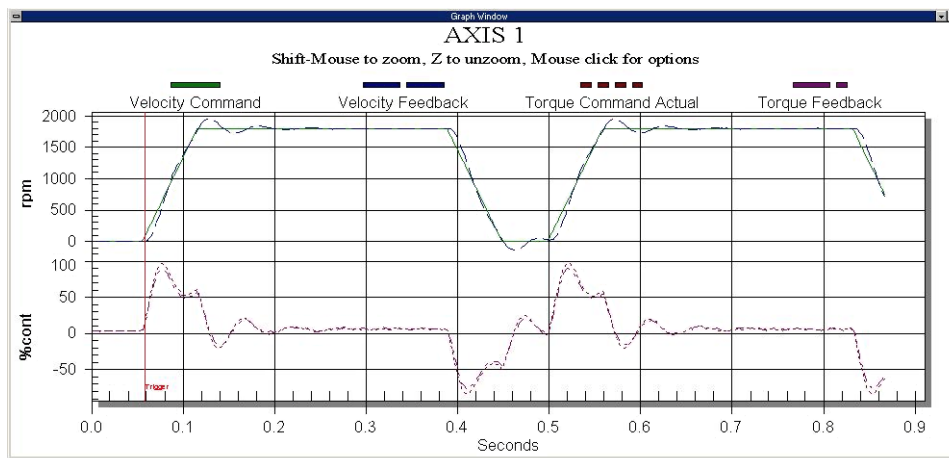


Figure 95: Default Inertia Setting (0)

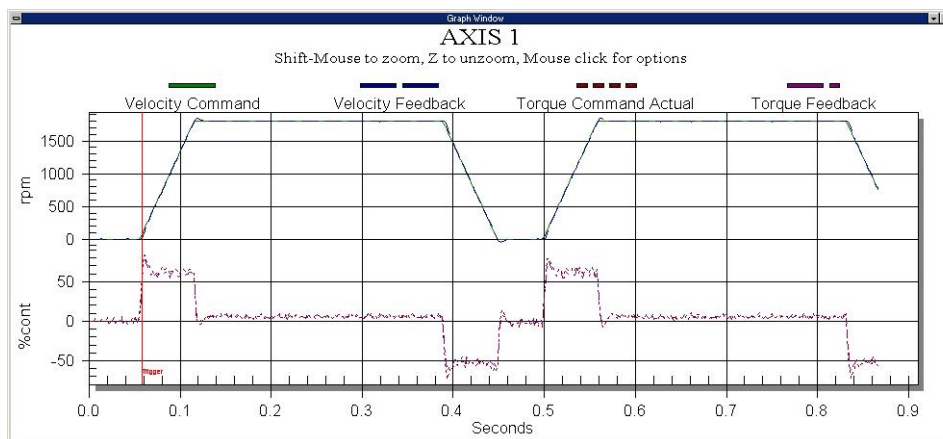


Figure 96: Inertia Setting (5)

## 2. Increase the response parameter

The Response is normally the next adjustment when tuning. For best performance the Response should be lower with a higher inertia mismatch (>10:1) and higher with a lower inertia mismatch.

This is because most higher inertia systems have torsional compliance in the frequency range of interest. Torsional compliance is specially noticed in a jaw type coupling with a rubber spider, or if there is a long drive shaft, the Response should be decreased. The highest recommended Response with High Performance Gains enabled is 100 Hz.

The next step in tuning the system to its optimal level is to move the response of the system up to the point of the desired system rigidity. A standard way of accomplishing this is to slowly increase the response of the system until the system becomes unstable (an audible noise will emit from the motor in the form of a buzz or hum). To verify stability at varying loads, this process should be completed with the smallest load on the motor shaft. Once a state of instability is reached back the response off by 20% to insure stable operation for years to come.

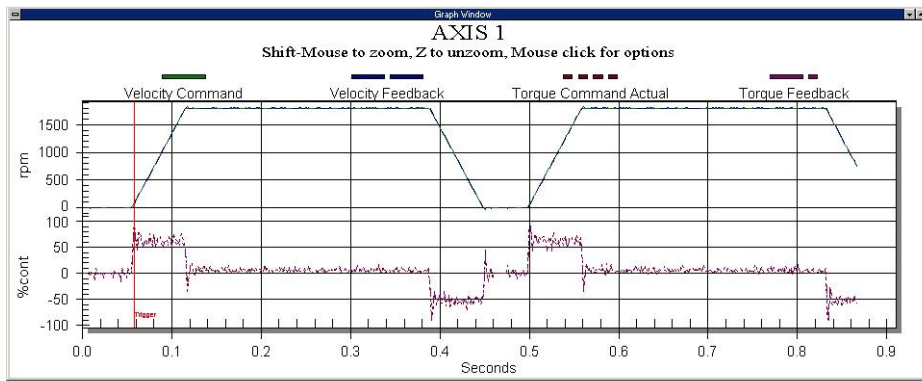


Figure 97: Inertia Setting (5) Response

### 3. Position Error Integral

The difference in motion when this parameter is disabled and enabled can be observed in the following graphs. The first graph shows motion with the position error integral turned off. The second graph shows motion with the position error integral enabled and the time constant set for 20ms. Note the settling time difference of the two indexes.

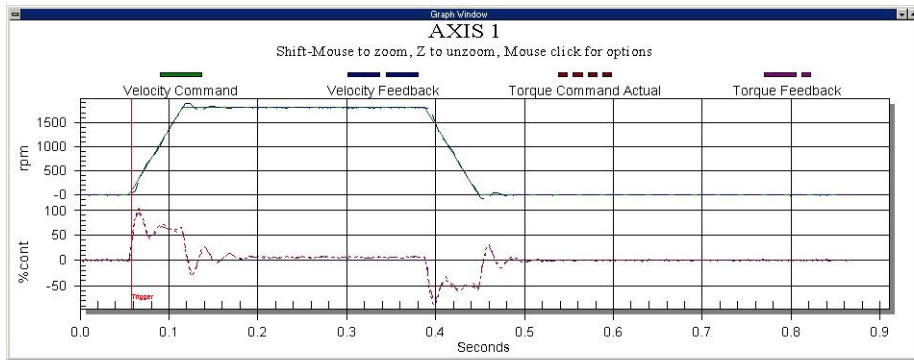


Figure 98: PEI = off

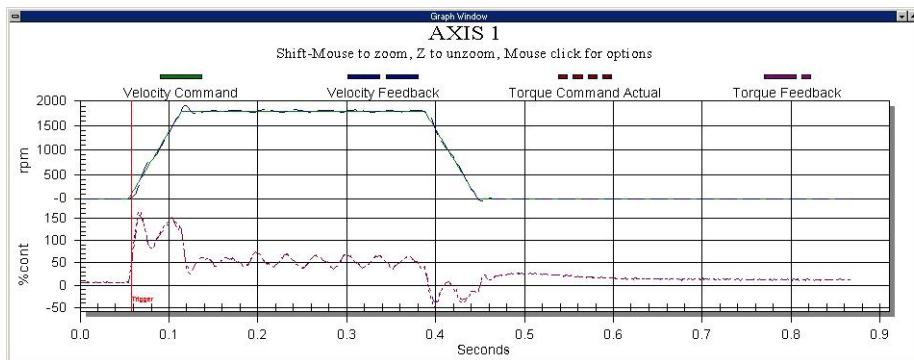


Figure 99: PEI = on

Feedforwards gain can be enabled if the performance requirements are very demanding. However, when using them make sure the Inertia Ratio and Friction values are an accurate representation of the load. Otherwise, the system performance can actually be degraded or stability will suffer. Enabling Feedforwards makes the system less tolerant of inertia or friction variations during operation.

# Tuning Parameters

## Inertia Ratio

Inertia Ratio specifies the load to motor inertia ratio and has a range of 0.0 to 50.0. A value of 1.0 specifies that load inertia equals the motor inertia (1:1 load to motor inertia). The drives can control up to a 10:1 inertia mismatch with the default Inertia Ratio value of 0.0. Inertial mismatches of over 50:1 are possible if response is reduced.

The Inertia Ratio value is used to set the internal gains in the velocity and position loops, including feedforward compensation if enabled.

To calculate the Inertia Ratio value, divide the load inertia reflected to the motor by the motor inertia of the motor. Include the motor brake as a load where applicable. The resulting value should be entered as the Inertia Ratio parameter.

$$IR = \frac{RLI}{MI}$$

Where:

IR = Inertia Ratio

RLI = Reflected Load Inertia (lb-in-sec<sup>2</sup>)

MI = Motor Inertia (lb-in- sec<sup>2</sup>)

If the exact inertia is unknown, a conservative approximate value should be used. If you enter an inertia value higher than the actual inertia, the resultant motor response will tend to be more oscillatory.

If you enter an inertia value lower than the actual inertia, but is between 10 and 90 percent of the actual, the drive will tend to be more sluggish than optimum but will usually operate satisfactorily. If the value you enter is less than 10 percent of the actual inertia, the drive will have a low frequency oscillation at speed.

There are three guidelines for defining the inertia ratio:

1. In most applications the default value of 0 (zero) will be used.
2. If the inertia of the machines varies or there is uncertainty in the estimate, use the lowest value for inertia.
3. The machine system bandwidth is reduced if the inertia estimate is low. Consequently a low inertia estimate can sometimes add a level of robustness.

## Friction

In the drive, this is a viscous friction parameter, characterized in terms of the rate of friction increase per 100 motor RPM. The range is 0.00 to 100.00 in units of percent continuous torque of the specified motor/drive combination. The Friction value can either be estimated or measured. For most servo drives viscous friction is 0.

If estimated, always use a conservative (less than or equal to actual) estimate. If the friction is completely unknown, a value of zero should be used. A typical value used here would be less than one percent.

If the value entered is higher than the actual, system oscillation is likely. If the value entered is lower than the actual a more sluggish response is likely but generally results in good operation.

## Response

The Response adjusts the velocity loop bandwidth with a range of 1 to 500 Hz. In general, it affects how quickly the drive will respond to commands, load disturbances and velocity corrections.

---

### Note

The drive's position velocity loop is designed to be a second order system with a gain of one, a natural frequency specified in the Response scroll box, and a damping factor of 0.8. If the drive's bandwidth is defined to be the -3dB point of the response, the idealized bandwidth of the system is approximately 2.2 times greater than the natural frequency.

---

For example: When the Response is set to 50, the idealized bandwidth is 110 Hz.

## High Performance Gains

Enabling High Performance Gains fundamentally affects the closed loop operation of the drive and greatly modifies the effect of the Response parameter. High Performance Gains are most beneficial when the Inertia Ratio and Friction parameters are accurate.

High Performance Gains, when enabled, make the system less forgiving in applications where the actual inertia varies or the coupling between the motor and the load has excessive windup or backlash.

---

### Note

When using an external position controller, High Performance Gains should not be enabled.

---

## Feedforwards

Feedforward gains are essentially open loop gains that generate torque commands based on the commanded velocity, accel/decel and the known load parameters (Inertia Ratio and Friction). Using the feedforwards reduces velocity error during steady state and reduces overshoot during ramping. This is because the Feedforwards do not wait for error to build up to generate current commands.

Feedforwards should be disabled unless the absolute maximum performance is required from the system. Using them reduces the forgiveness of the servo loop and can create instability if the actual inertia and/or friction of the machine varies greatly during operation or if the Inertia Ratio or Friction parameters are not correct.

The internal feedforward velocity and acceleration gains are calculated by using the Inertia Ratio and Friction parameters. The feedforward acceleration gain is calculated from the Inertia Ratio parameter and the feedforward velocity gain is calculated from the Friction parameter.

When Feedforwards are enabled, the accuracy of the Inertia Ratio and Friction parameters is very important. If the Inertia Ratio parameter is larger than the actual inertia, the result would be a significant velocity overshoot during ramping. If the Inertia parameter is smaller than the actual inertia, velocity error during ramping will be reduced but not eliminated. If the Friction parameter is greater than the actual friction, it may result in velocity error or instability. If the Friction parameter is less than the actual friction, velocity error will be reduced but not eliminated.

Feedforwards can be enabled in any operating mode, however, in certain modes they do not function. These modes are described in table below.

Operating Mode	Feedforward Parameters Active	
	Accel FF	Vel FF
Analog Velocity	No	Yes
Preset Velocity	Yes	Yes
Pulse/Position	No	No
Summation	No	Yes

## Low Pass Filter Group

The Low Pass Filter will reduce machine resonance due to mechanical coupling and other flexible drive/load components by filtering the command generated by the velocity loop. A check box on the Tuning view enables a low pass filter applied to the output of the velocity command before the torque compensator. The low pass filter frequency parameter defines the low pass filter cut-off frequency. Signals exceeding this frequency will be filtered at a rate of 40 dB per decade. The default value is 600Hz.

## Line Voltage

Line Voltage specifies the applied power and adjusts the internal gains to compensate for it. This parameter has two choices 115 Vac and 230 Vac. If the Line Voltage is set to 230 Vac when the actual applied voltage is 115 Vac, the motor will be slightly less responsive to commands and load disturbances.

---

### WARNING

The Line Voltage must never be set to 115 Vac if the applied voltage is actually 230 Vac. This can cause drive instability and failure.

---

## Determining Tuning Parameter Values

For optimum performance you will need to enter the actual system parameters into the drive. This section discusses the methods which will most accurately determine those parameters.

---

### Note

If you have an application which exerts a constant unidirectional loading throughout the travel such as in a vertical axis, the inertia tests must be performed in both directions to cancel out the unidirectional loading effect.

---

### Initial Test Settings

When running the tests outlined in this section, the motor and drive must be operational so you will need to enter starting values.

If your application has less than a 10:1 inertia mismatch, the default parameter settings will be acceptable. If the inertial mismatch is greater than 10:1, use the following table for initial parameter settings.

Parameter	Setting
Friction	0.00
Inertia Ratio	1/3 to 1/2 Actual
Response	500/Inertia Ratio
High Performance Gains	Disabled
Feedforwards	Disabled
Line voltage	Actual Applied

### Determining Inertia Ratio

Actual system Inertia Ratio is determined by accelerating and decelerating the load with a known ramp while measuring the torque required.

Consider the following before determining the inertia:

- If your application allows a great deal of motor motion without interference, it is recommended that you use a Preset Velocity to produce accurate acceleration ramps.
- If your application has a very limited range of motion, it is recommended that you use a position controller to produce the acceleration ramps and to prevent exceeding the axis range of motion.
- The accel and decel ramp should be aggressive enough to require at least 20 percent of continuous motor torque. The higher the torque used during the ramp, the more accurate the final result will be.
- With ramps that take less than 1/2 second to accelerate, read the Diagnostic Analog Outputs with an oscilloscope to measure the Torque Feedback.
- With ramps that take 1/2 second or longer to accelerate, read the Torque Command parameter on the Motor view of PowerTools Pro or with the Watch Window.
- To best determine the inertia, use both acceleration and deceleration torque values. The difference allows you to drop the constant friction out of the final calculation.
- If your application exerts a constant “unidirectional loading” throughout the travel such as in a vertical axis, the inertia test profiles must be performed in both directions to cancel out the unidirectional loading effect.
- The Torque Command Limited and Velocity Feedback parameters can be measured using the drive’s Analog Outputs, PowerTools Pro software or an FM-P.

An oscilloscope will be needed for systems with limited travel moves and rapidly changing signals of torque and velocity.

Inertia Measurement Procedure:

---

### Note

The test profile will need to be run a number of times in order to get a good sample of data.

---

1. Enable the drives and run the test profiles.
2. Note the Torque Command Limited value during acceleration and deceleration.

3. Use the appropriate formula below to calculate the inertia.

For horizontal loads or counterbalanced vertical loads use the following formula:

$$IR = \frac{(R \cdot V_m (T_a + T_d))}{2000} - 1$$

Where:

- IR = Inertia Ratio
- R = ramp in ms/kRPM
- T<sub>a</sub> = (unsigned) percent continuous torque required during acceleration ramping (0 - 300)
- T<sub>d</sub> = (unsigned) percent continuous torque required during deceleration ramping (0 - 300)
- V<sub>m</sub> = motor constant value from Table 18 below

For un-counter balanced vertical loads use the following formula:

$$IR = \frac{(R \cdot V_m (\tau_u + \tau_{du} + \tau_{da} + \tau_{dd}))}{4000} - 1$$

Where:

- IR = Inertia Ratio
- R = ramp in ms/kRPM
- V<sub>m</sub> = motor constant value from the table below
- τ<sub>u</sub> = (unsigned) percent continuous torque required during acceleration ramping while moving up (against the constant force)
- τ<sub>du</sub> = (unsigned) percent continuous torque required during deceleration ramping while moving up (against the constant force)
- τ<sub>da</sub> = (unsigned) percent continuous torque required during acceleration ramping while moving down (aided by the constant force)
- τ<sub>dd</sub> = (unsigned) percent continuous torque required during deceleration ramping while moving down (aided by the constant force)

## Ramp Units Conversion

If you are using an external position controller to generate motion you may need to connect the ramp units as desired below.

Many position controllers define acceleration in units per sec<sup>2</sup>. The formulas above use ms/kRPM. Make sure you make this conversion when entering the information into the formula.

Conversion Formula:

$$MPK = \frac{10^6}{(RPSS \cdot 60)}$$

Where:

- MPK = accel ramp in ms/kRPM
- RPSS = accel ramp in revolutions per second<sup>2</sup>

Motor	Drive	V <sub>m</sub>	Percent Continuous/volt (default scaled Torque Command)	RPM /volt (default scaled Actual Velocity)
MG-205	EN-204	4.77	30	600
MG-208		5.11	30	600
MG-316		3.17	30	600
NT-320		4.3	30	600

Motor	Drive	Vm	Percent Continuous/volt (default scaled Torque Command)	RPM /volt (default scaled Actual Velocity)
MG-316	EN-208	3.17	30	600
MG-340		3.14	30	600
MG-455		2.44	30	600
NT-320		5.16	30	600
NT-330		6.87	30	600
NT-345		6.72	30	600
NT-355		5.97	30	600
MG-455	EN-214	2.44	30	600
MG-490		1.85	30	600
MG-4120		1.69	30	600
NT-345		6.72	30	600
NT-355		5.97	30	600
NT-207	Ei-202	7.16	30	600
NT-212		9.22	30	600
MG-205		5.00	30	600
MG-208		6.47	30	600
NT-207	Ei-203	7.16	30	600
NT-212		12.40	30	600
MG-205		5.00	30	600
MG-208		8.25	30	600
MG-316		15.68	30	600





# Diagnosics and Troubleshooting

## Diagnostic Display

The diagnostic display on the front of the drive shows drive, base drive and FM-2 Module status and fault codes. When a fault condition occurs, the drive will display the fault code, overriding the status code.

The decimal point is “On” when the drive is enabled and the stop input is not active. This indicates that the drive is ready to run and any motion command will cause motion. Motion commands will not cause motion unless you are Ready (R) and the decimal point is “On”.

Display Indication	Status	Description
b	Brake Engaged (Output “Off”)	Motor brake is mechanically engaged. This character will only appear if the Brake output function is assigned to an output line.
d	Disabled	Power Stage is disabled.
R	Ready	The Epsilon or FM-2/MDS drive system is functioning normally and is ready to execute a motion command.
X	Indexing	Index in progress. Other motion commands do not function.
J	Jogging	Jog function in progress. Other motion commands do not function.
H	Homing	Home cycle in progress. Other motion commands do not function.
T	Torque Mode	Analog Torque Mode Operation
V	Velocity Mode	Analog Velocity Mode Operation
P	Pulse Mode	Pulse Mode Operation
S	Stop or Travel Limit Decel	<i>Stop or Travel Limit Decel</i> in progress.
L	RMS Foldback	Motor torque is limited to 80 percent.

Display Indication	Status	Description
C	Stall Foldback (EN drive only)	Drive output current is limited to 80 percent of drive stall current.
•	Ready to Run	Drive enabled, no <i>Stop</i> input.


## Fault Codes

A number of diagnostic and fault detection circuits are incorporated to protect the drive. Some faults, like high DC bus and amplifier or motor over temperature, can be reset with the Reset button on the front of the drive or the Reset input function. Other faults, such as encoder faults, can only be reset by cycling power “Off” (wait until the diagnostics display turns “Off”), then power “On”.

The drive accurately tracks motor position during fault conditions. For example, if there is a “Low DC Bus” fault where the power stage is disabled, the drive will continue to track the motor’s position provided the logic power is not interrupted.

The +/- Limit faults are automatically cleared when the fault condition is removed. The table below lists all the fault codes in priority order from highest to lowest. This means that if two faults are active, only the higher priority fault will be displayed.

Display	Fault	Action to Reset	Bridge Disabled
✱	Flash Invalid	Reprogram the Flash	Yes
A	Drive Overtemp (Epsilon drive only)	Allow Drive to Cool down, Cycle Power or Cycle Logic Power	Yes
I	Power Up Test	Cycle Power or Cycle Logic Power	Yes
N	NVM Invalid	Reset Button or Input Line	Yes
U	Invalid Configuration	Reset Button or Input Line	Yes
Z	Power Module	Reset Button or Input Line Cycle Logic Power (MDS)	Yes
H	High DC Bus	Reset Button or Input Line	Yes
L	Low DC Bus	Reset Button or Input Line	Yes
E	Encoder State	Cycle Power or Cycle Logic Power	Yes

Display	Fault	Action to Reset	Bridge Disabled
E	Encoder Hardware	Cycle Power or Cycle Logic Power	Yes
M	Motor Overtemp	Allow Motor to cool down, Reset Button or Input Line	Yes
N	RMS Shunt Power	Reset Button or Input Line	Yes
O	Overspeed	Reset Button or Input Line	Yes
F	Following Error (Position mode) (Pulse mode)	Reset Button or Input Line	Yes
L	Travel Limit +/-	Auto	No
	All "On"	Normally "On" for one second during power up	Yes

## Fault Descriptions

✱

### Flash Invalid

This fault indicates that the firmware checksum has failed. From the Tools menu, Flash Upgrade to reprogram/upgrade the firmware stored in flash memory. If this problem persists, call Control Techniques. A common cause would be an interrupted F/W Flash upgrade (cable disconnected in the middle of an upgrade process).

Ⓜ

### Drive Overtemp

Indicates the drive IGBT temperature has reached 100°C (212°F).

I

### Power Up Test

This fault indicates that the power-up self-test has failed. This fault cannot be reset with the reset command or reset button.

N

### NVM Invalid

At power-up the drive tests the integrity of the non-volatile memory. This fault is generated if the contents of the non-volatile memory are invalid.

U

### Invalid Configuration



### Epsilon Only

If this occurs call Technical Support at Control Techniques.

The FM was not on this drive during its previous power-up and it is not known if the setup data in the FM matches the drive and motor to which the FM is now attached.

This can also happen when a FM is removed from a drive and the drive is powered-up.

To reset the fault, create or open a configuration file with the correct drive and motor selections and download the configuration to the FM or drive. If you are certain that the setup data in the FM or drive matches the system configuration, press and hold the drive's Reset button for 10 seconds (until the fault is cleared).

**⚠ CAUTION**

Damage may occur to the drive, motor or both if the fault is cleared using the Reset button when the setup data in the FM does not match the current drive and motor.

**Z Power Module**

This fault is generated when a power stage over-temperature, over-current or loss of power stage logic supply occurs. This can be the result of a motor short to ground, a short in the motor windings, a motor cable short or the failure of a switching transistor.

It can also occur if the drive enable input is cycled "Off" and "On" rapidly (>10 Hz).

**H High DC Bus**

This fault will occur whenever the voltage on the DC bus exceeds 440 Vdc. The most likely cause of this fault would be an open shunt fuse, a high AC line condition or an application that requires an external shunt (e.g., a large load with rapid deceleration).

**⏚ Low DC Bus**

This fault will occur whenever the voltage on the DC bus drops below 60 volts. The most likely cause of this fault is a reduction (or loss) of AC power. A 50 ms debounce time is used with this fault to avoid faults caused by intermittent power disruption. For some types of custom motors it may be necessary to disable this fault. Refer to the Advanced Tab section of Setting Up Parameters for more information.

**E Encoder State**

Certain encoder states and state transitions are invalid and will cause the drive to report an encoder state fault. This is usually the result of noisy encoder feedback caused by poor shielding. For some types of custom motors it may be necessary to disable this fault. See Faults view section for more information.

**E Encoder Hardware**

If any pair of encoder lines are in the same state, an encoder line fault is generated. The most likely cause is a missing or bad encoder connection.

**M Motor Overtemp**

This fault is generated when the motor thermal switch is open due to motor over-temperature or incorrect wiring.


**⚡ RMS Shunt Power**

**EN E Series Only**

This fault is generated when RMS shunt power dissipation is greater than the design rating of the internal shunt.

**⏚ Overspeed**

This fault occurs when the actual motor speed exceeds the Overspeed Velocity Limit parameter. This parameter can be accessed with PowerTools Pro software.

F	<b>Max Following Error</b>
This fault is generated when the following error exceeds the following error limit (default following error limit is 0.2 revs). With PowerTools Pro you can change the Following Error Limit value or disable it on the Position view.	
L	<b>Travel Limit +/-</b>
This fault is caused when either the + or - Travel Limit input function is active.	
	<b>All "On"</b>
This is a normal condition during power up of the drive. It will last for less than 1 second. If this display persists, call Technical Service at Control Techniques.	

## Diagnostic Analog Output Test Points

The DGNE cable was designed to be use with either an oscilloscope or a meter. The wires are different lengths to avoid shorting to each other. However, if signals do get shorted to GND, the drive will not be damaged because the circuitry is protected.

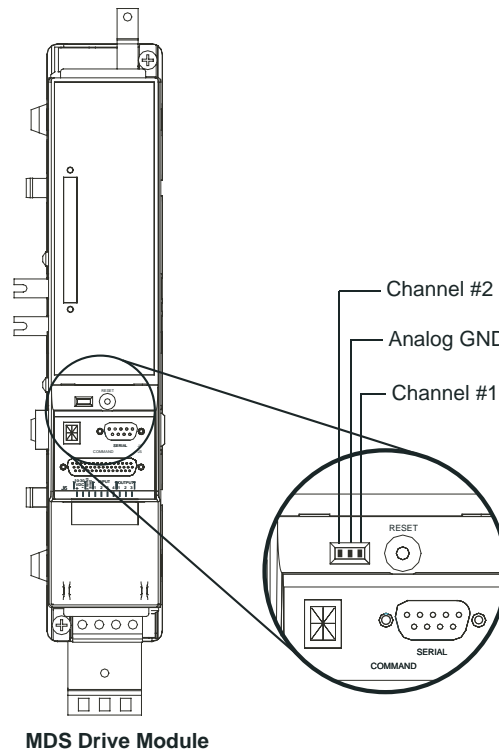


Figure 100: Diagnostic Output Test Points

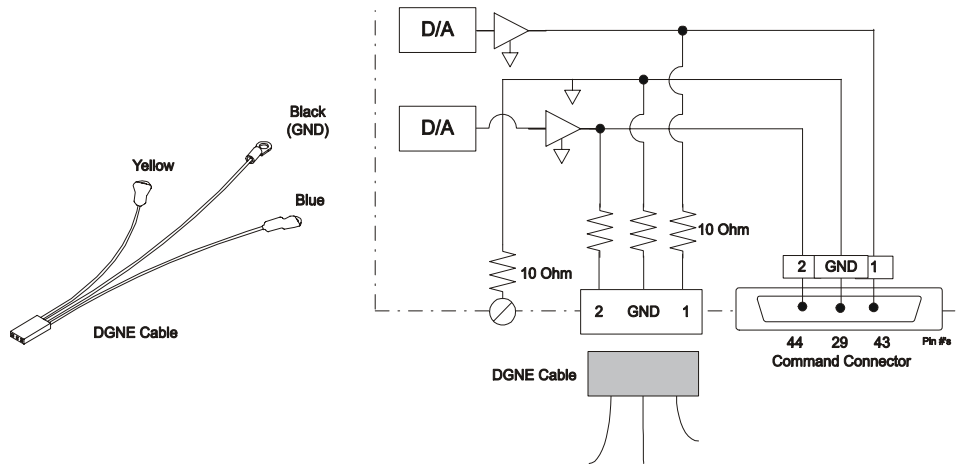


Figure 101: Diagnostic Cable (DGNE) Diagram

# Drive Faults

## Faults View

The Faults view displays any active faults in the system. Those faults that do not require a reboot, can be cleared by clicking on the *Reset* button on the front of the drive or module.

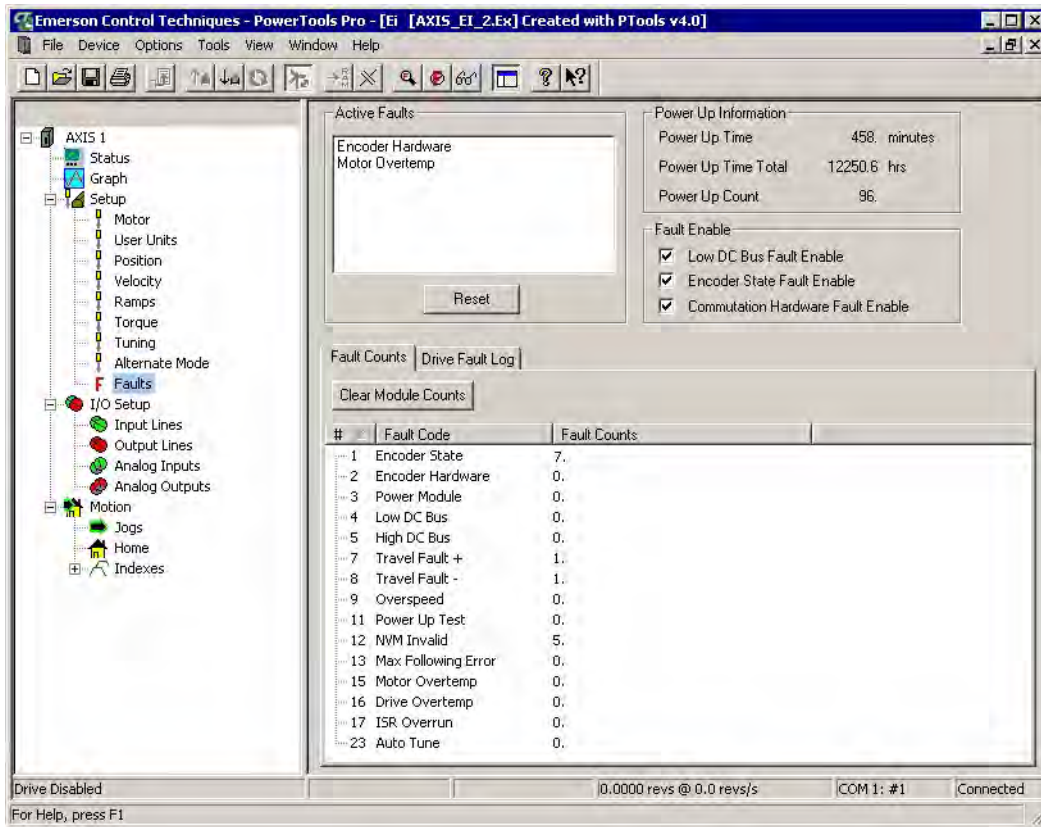


Figure 102: Faults View

## Resetting Faults

Some drive faults are automatically reset when the fault condition is cleared. Others require drive power to be cycled, logic power to be cycled, or the drive to be “rebooted” to be cleared. If you wish to continue working in the PowerTools Pro software without resetting the fault, click the *Ignore Fault* button.

To reset faults that can be reset with the *Reset* button, simply click the *Reset* button in the Faults view or push the *Reset* button on the front of the drive where the fault occurred.

## Viewing Active Drive Faults

To view all active drive faults, select the *View Faults* command from the **Device** menu when online with the drive.

## Rebooting the Drive

To reboot the drive, cycle power or select the *Reboot Drive* command from the **Device** menu. This command reboots the drive attached to the active Configuration Window.

## Watch Window

PowerTools Pro contains a diagnostic utility called the Watch Window. The Watch Window can be used while PowerTools Pro is running and the PC is online with the device. The Watch Window allows the user to monitor the status of all the desired system parameters in one location. An example of the Watch Window is found in Figure 104 below.

To setup the Watch Window, select Tools\Watch Window from the PowerTools Pro menu. If not online with the device, the Watch Window will be unavailable on the menu. Upon selecting Watch Window, the following Select Parameters window will appear.

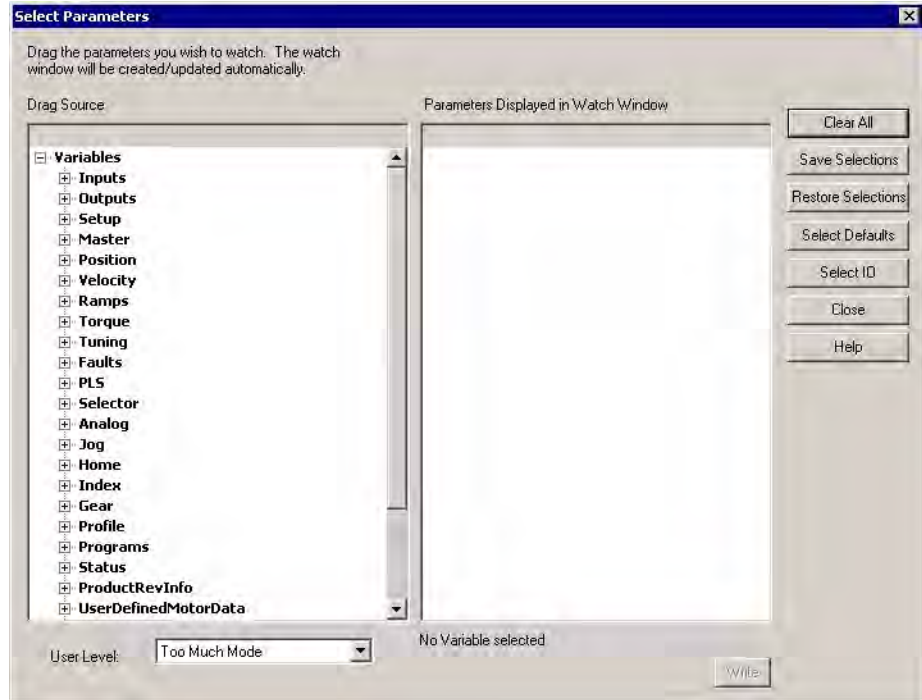


Figure 103: Watch Window - Select Parameters Window

The Select Parameters window as seen in Figure 103 allows the user to specify which parameters are to be seen in the Watch Window. To select a parameter for the Watch Window, simply double-click on the parameter in the "Drag Source" window or drag and drop the parameter from the "Drag Source" window on the left over to the "Parameters Displayed in Watch Window" on the right and it will be added to the Watch Window.



Parameter Name	Value
Axis Name	Axis 1
Axis Address	1
PosnCommand	0.0000revs
PosnFeedback	0.0000revs
FollowingError	0.0000revs
PosnFeedbackInCounts	0counts
VelCommand	0revs/m
VelFeedback	0revs/m
TorqueCommand	0.0% Cont
TorqueCommandLimited	0.0% Cont
FoldbackRMS	0.0% cont.
ShuntPowerRMS	0.0%
MasterAxis.PosnFeedback	0.0000Revs
MasterAxis.PosnFeedbackInCounts	0counts
DriveEnableStatus	False
Feedhold	False
Brake.Disengaged	False
CommandingMotion	False
AbsolutePosnValid	False
InPosn	False
AtVel	False
PowerStageEnabled	False
FoldbackActive	False
ShuntActive	False
TorqueLevelActive	False
TorqueLimitActive	False

Figure 104: The Watch Window

Once a parameter is added to the Watch Window, it's current value or state is constantly monitored. If a parameter in the window changes value or state, it will change to a red color. It will remain red until it hasn't changed for a period of 4 seconds. After 4 seconds, the parameter will turn back to black in color. This allows the user to see what has changed recently without looking directly at every parameter.

The following are descriptions of the buttons and controls on the Select Parameters window:

#### Clear All Button

This button is used to clear all the parameter selections in the "Parameter Displayed in Watch Window" pane that were previously selected and the Watch Window will close.

#### Save Selections Button

This button saves the parameter selections. This enables the user to restore the same list of parameters for use in future online sessions. Once the selections have been saved, the Restore Selections button can be used to monitor all the same parameters the next time the user opens the Watch Window. Therefore, if there is a list of helpful diagnostic parameters the user wishes to see when online, those specific parameters can be saved and recalled in the Watch Window at any time. The settings are saved in a file named "fm3watch.wch"

#### Restore Selections Button

This button restores the parameter selections that were last saved using the Save Selections button. This enables the user to restore the list of parameters created in a previous online session.

#### Select Defaults

The Select Defaults button adds the most commonly used parameters to the Watch Window.

#### Select I/O

The Select I/O button will add the module/base drive or drive digital inputs and outputs to the Watch Window.

#### Close

The Close button will close the Select Parameters window, while the Watch Window will remain open.

#### Help

The help button will give associated help on the Watch Window setup.

## Error Messages

PowerTools Pro will pop-up an error message box to alert you to any errors it encounters. These message boxes will describe the error and offer a possible solution.

The table below list the of common problems you might encounter when working with PowerTools Pro software along with the error message displayed, the most likely cause and solution.

Problem/Message	Cause	Solution
Time-out while waiting for device response. The attempted operation has been cancelled. (see fault: No device selected)	Loss of serial communications.	Check the serial connection to the device and try operation again.
The attached device(s) do not have valid revisions, or do not have matching revisions.	Attempting to broadcast to drive without matching firmware revisions.	Program each drive individually.
Unable to communicate with device [Address x]	The device that you are attempting to communicate with is no longer available.	Check all connections and verify that you are using the correct baud rate then try again.
The specified drive type (name) does not match the actual drive type (name). Please make necessary corrections.	The drive type you selected in the "Drive Type" list box does not match the drive you are downloading to.	Change the drive type selected in the "Drive Type" list box to match the drive you are downloading to.
Non-Control-Techniques device attached (address). When trying to program more than one drive, only EMC drives of the same type can be attached to the network.	This error is caused When you attempting to perform an upload or download to multiple drives and one or more of the drives are not the same type.	Disconnect the device(s) that has been specified and try the operation again or program each device individually.
You have changed a parameter which will not take effect until the drive has been rebooted. Before you reboot the drive, you will need to save your setup to NVM. Do you wish to save your setup to drive NVM now?	See message.	Yes/No.
(Operation Name) The attempted operation has been cancelled.	Communication error.	Retry operation. Check connection to drive.
Invalid entry. The entry exceeds the precision allowed by this field. The finest resolution this field accepts is (value).	Entered a value out of range.	Enter a value within the range of that field. The status bar displays information on the currently selected object or action.
The device was disconnected during the upload. The upload was not complete.	Connection to the device was lost (a time-out occurred).	Check the connection to the device and try again.
The device was disconnected during the download. The download was not complete.	Connection to the device was lost (a time-out occurred).	Check the connection to the device and try again.
No device selected.	The device you are attempting to communicate with is not responding.	Check all connections. Verify the baudrate. Verify that the "Maximum Node Address" value is at least the value of the address of the drive connected.

# User Defined Motors

Drives can be configured to operate with brushless DC (synchronous permanent magnet) motors not manufactured by Control Techniques. This feature is very useful for users who are retrofitting drives on existing systems or who have special motor requirements.

## Commutation Basics

To properly commutate the motor, the drive must know the electrical angle (the angle between the motor magnetic field and stator coils; R, S and T). At power-up, the drive determines the starting electrical angle from the U, V and W commutation tracks. After this is determined, the U, V and W commutation tracks are ignored and the commutation is entirely based on the A and B incremental channels. The number of U, V and W cycles must match the number of poles in the motor but they do not have to be aligned with the motor poles in any particular way.

The U, V and W tracks have a fairly coarse resolution, therefore, on power-up, the commutation accuracy is limited to  $\pm 30$  electrical degrees from optimum. When the Z channel is seen by the drive, the commutation angle is gradually shifted to the optimum position as defined by the Motor Encoder Marker Angle parameter. This shift is accomplished in about one second whether the motor is rotating or not.

### Tools Required:

- Oscilloscope dual trace 5 Mhz bandwidth minimum.
- AC/DC voltmeter, 20 Vdc and 200 VAC minimum.
- Drill motor (reversible) or some means of spinning the motor.
- Coupling method between the drill motor and the test motor.
- 5 Vdc power supply to power the motor encoder.
- Motor power cable (CMDS or CMMS).
- Motor feedback cable (CFCO).
- Terminal strip (18 position suggested) to conveniently connect the motor power and encoder wires during testing.
- Method to securely hold the motor during operation (a vise or large C-clamp).

## Procedure

The steps required to assemble a servo system consisting of a drive, and a non-Control-Techniques motor are listed below:

1. Determine if your motor is compatible with the drive by verifying its characteristics. There are a number of restrictions such as encoder line density and motor pole count that must be considered. Most of these parameters are commonly found on a motor data sheet and some may have to be determined by testing.

It is important that the encoder used have a repeatable Z channel angle with reference to one of the commutation channels. This is especially the case if you will be using the same encoder on several motors and you wish to use the same setup file on them all. Otherwise you will need to generate a motor file for each individual motor/encoder.

2. Design and assemble the cabling and interface circuitry required to connect the motor and drive. Motor and feedback cables must be properly shielded and grounded.
3. Determine the encoder alignment. In order to commutate a motor correctly the angular relationship of the encoder commutation tracks and the marker pulse with respect to the R, S and T windings in the stator must be known.
4. Enter the motor/encoder data into the MOTOR.DDF file. This data is then read by the PowerTools Pro software when setting up the drive.
5. Test your system to verify that the servo system is working correctly.

## Step 1: Motor Wiring

The first step is to wire the motor terminals to the drive. Control Techniques designates the motor terminals as R, S and T.

Use the following procedure to establish the R, S and T mapping:

1. Assume the motor terminals of the non-Control-Techniques motor are designated A, B and C. If they are not marked, name the terminals randomly. The next steps will determine their working designations.
2. You can select any of the three motor terminals and call it R. In this procedure we will choose terminal A.

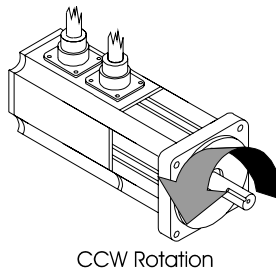
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**⚠ WARNING**

The rotation of the motor will generate dangerous voltages and currents on the motor phase leads. Make sure the wires and connections are properly insulated.

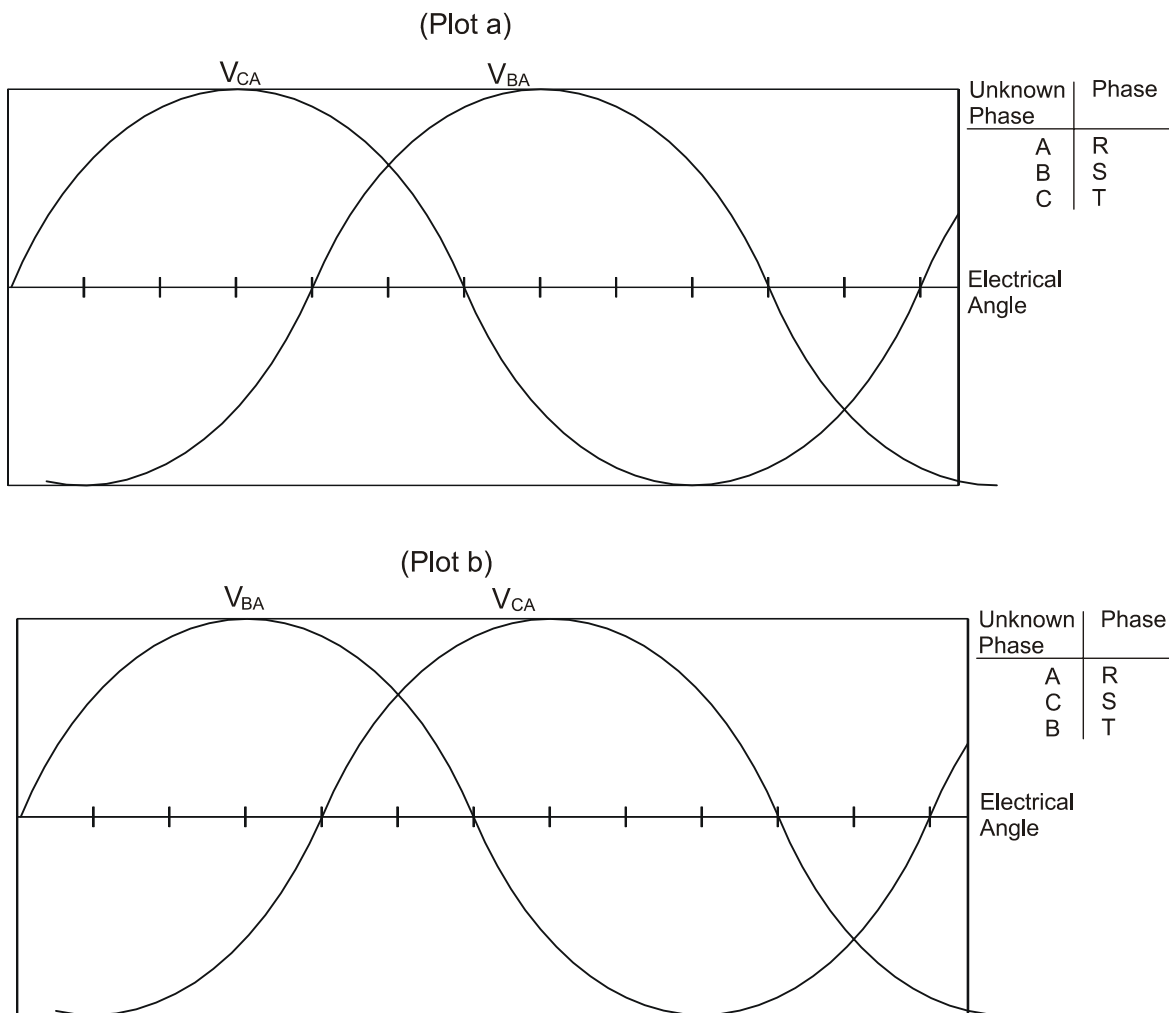
---

3. Connect the scope to read VCA and VBA. VCA and VBA are measured by putting the probe ground clips on A and the scope probes on C and B.
4. Rotate the motor CCW (i.e., rotate the shaft counter-clockwise as you face the shaft end of the motor).



*Figure 105: CCW Rotation of the Motor*

5. Look at the phase-to-phase voltages VCA and VBA. There are two possibilities. If VCA leads VBA, then assign B to S and C to T. If VCA leads VBA, then assign B to T and C to S. These relationships are summarized in the figure below.



Phase plot obtained by rotating the motor in the CCW direction (the CCW direction is determined from the front face of the motor). This figure shows the motor terminal mapping to be used when  $V_{CA}$  leads  $V_{BA}$  (Plot a), and when  $V_{BA}$  leads  $V_{CA}$  (Plot b).

Figure 106: Phase Plot Used to Determining Stator Wiring

**Note**

For the remainder of this procedure we will refer to the motor terminals using the Control Techniques designations R, S and T.

**Step 2: Motor Feedback Wiring**

This step describes how to wire the feedback signals to the drive. There are two parts to this step: electrical interfacing and logical interfacing.

**Encoder Electrical Interfacing**

Each of the encoder signals is received by a differential receiver to minimize the noise susceptibility and to increase frequency bandwidth. This requires two wires for each logical signal. (i.e., signal A requires channel A and A/, etc.).

For optimum performance these signals should be generated by an encoder with a line driver output. Encoders which supply only single ended output signals will require some interfacing circuitry.



- Voltage rating min: 10 Vdc
- I capacity min: 1 mA

## Encoder Logical Interfacing

The encoder is expected to provide six logical signals: A, B, Z, U, V and W. Each of these signals is received at the drive by a differential receiver circuit. For example, the A logical signal is received as channels A and /A.

Signals A and B provide incremental motor position in quadrature format. Z is a once per revolution marker pulse. U, V and W are commutation tracks.

There are two steps in interfacing the encoder signals:

1. Determine whether your encoder has all the required signals to operate with a drive. Some encoders, for example, do not provide a marker pulse or the marker pulse may not have a fixed phase relationship to the commutation tracks.
2. Determine the mapping from the motor encoder signals to the drive. To help with this second step we have provided a description of the required characteristics of the A, B, Z, U, V and W encoder signals.

The signal relationships of A, B, U, V and W required by the drive are shown in the phase plots below. For clarity the time scale against which A and B are plotted is different from that which U, V and W are plotted. Note that A leads B and U leads V and V leads W.

Plots like these are obtained by powering the encoder then rotating the motor while observing the signals on an oscilloscope. It is important to note which direction of motor rotation (CW or CCW) generates the phasing shown in the figures below.

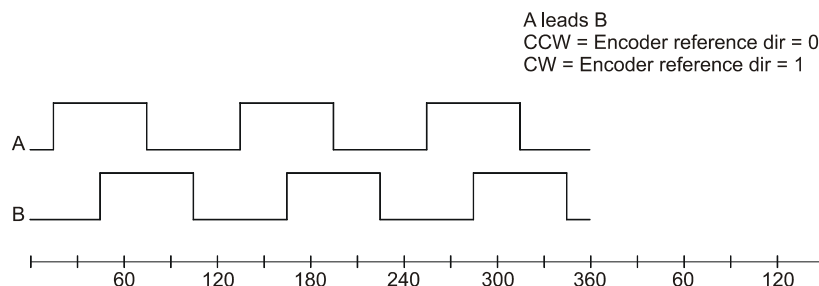


Figure 109: Phase Plot of A and B Encoder Channels

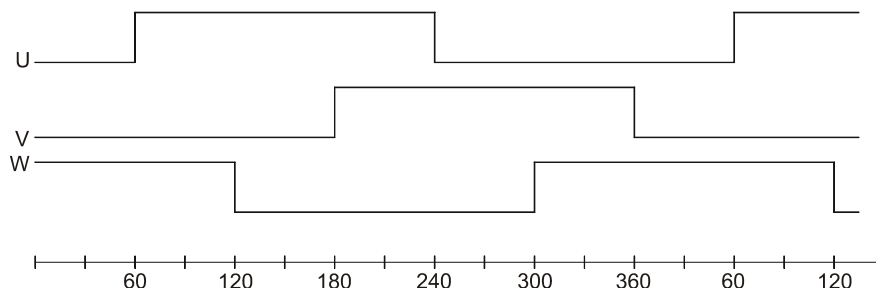


Figure 110: Phase Plot of U, V and W Encoder Signals with CCW Rotation

If the signal phasing in the figure above is obtained by rotating the motor -, the Motor Encoder Reference Motion is defined as - and the Motor Encoder Reference Motion parameter is set to 0. If the signal phasing in the figure above is obtained by rotating the motor +, then the Motor Encoder Reference Motion is defined as + and the Motor Encoder Reference Motion is set to 1.

---

### Note

It is important that all the encoder phases match the phase plot in the figure above. (i.e., A leads B, U leads V and V leads W. No particular phase relationship is required between the A and B pair and the U, V, W signals.

---

Drive signal names are relatively standard. Your encoder signals may be named differently or they may have the same names but the signals may be functionally different. You must determine the proper encoder signal mapping to correctly wire your encoder to a drive.

**CAUTION**

Encoder signals are used for commutation. Incorrectly wired encoder signals can cause damage to the drive.

**Step 3: Determine Encoder Alignment**

In order for the drive to commutate with a motor correctly, it must know how the encoder commutation tracks and how the marker pulses are aligned with respect to the R, S and T windings in the stator. The drive does not require any particular alignment position but instead allows the alignment to be specified using the Motor Encoder U Angle and Motor Encoder Marker Angle parameters.

If the motor under test has a defined encoder alignment which is repeated on all similar motors, simply determine the proper angles then use the same settings on all similar motors.

If the motor under test does not have a specific encoder alignment, you should establish some standard mechanical alignment before determining and setting the encoder electrical angles. This will allow you to replace the motor with another one in the same alignment without going through this procedure each time.

**Reading Encoder Alignment**

The reference motion for this test can be either CW or CCW. We will first use CCW. An oscilloscope will be used to monitor the signals. This procedure must be performed with the motor disconnected from the drive with the exception of the encoder power supply.

**CAUTION**

Be careful when using the drive encoder power supply for testing a motor. Shorting the 5V drives encoder power supply will blow an internal fuse which can only be replaced at the factory.

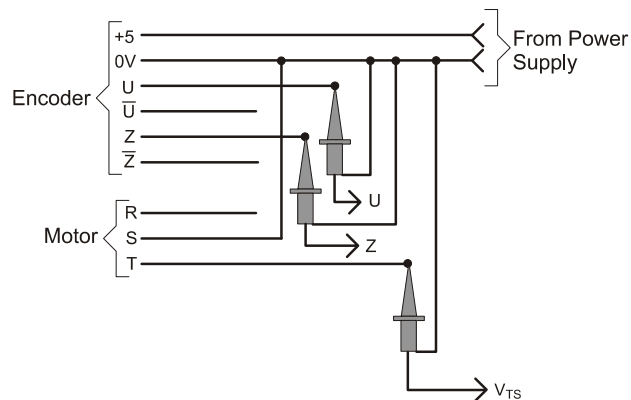


Figure 111: Oscilloscope Connections

**CCW Reference Rotation**

Before reading the motor signals, zero the  $V_{TS}$  oscilloscope channel on a horizontal graduation marker to allow more accurate readings.

Couple the drill motor to the motor shaft. While spinning the motor counter-clockwise, use an oscilloscope to examine the phase relationship between encoder channel U and positive peak of  $V_{TS}$  (the voltage at motor power terminal T with reference to S).

Use the figure below to determine the electrical angle at which the rising edge of U occurs. This is the Motor Encoder U Angle. Note that with a CCW reference rotation the positive peak of  $V_{TS}$  is at zero electrical degrees and the electrical angle decreases from left to right.



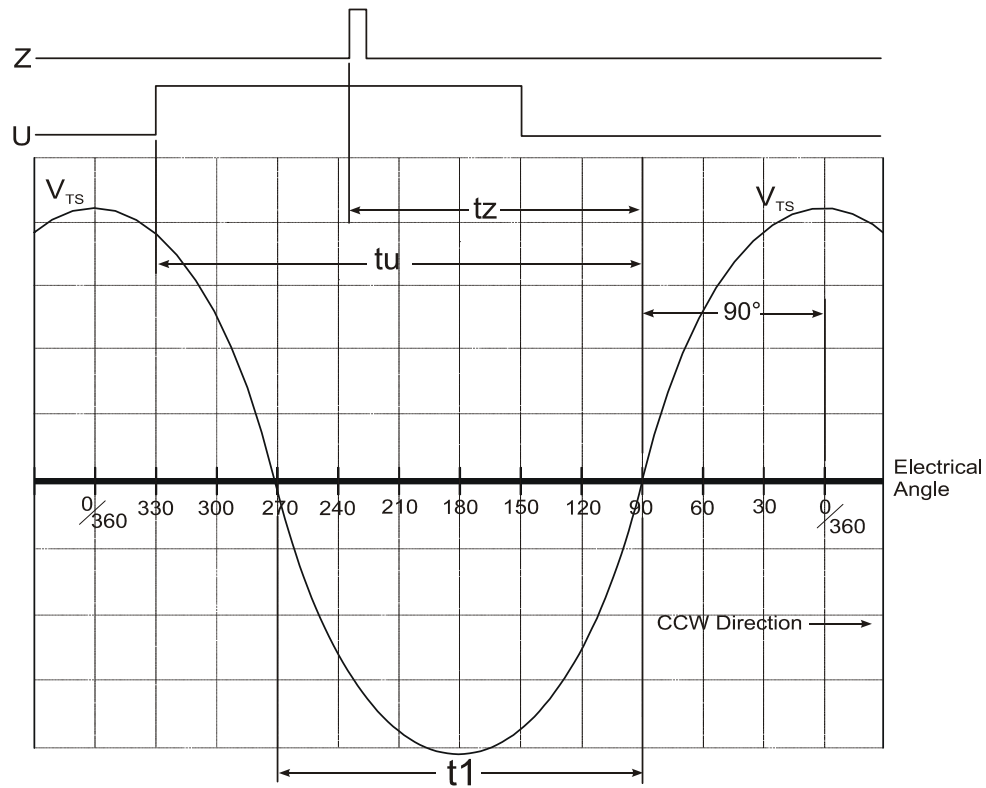


Figure 112: CCW Electrical Angle Plot

$$EUA = 90^\circ + \left( tu \frac{180}{t1} \right)$$

Where:

EUA = Motor Encoder “U” Angle

If EUA is >360° subtract 360°.

Next, use the oscilloscope to examine the phase relationship between Z and  $V_{TS}$ . Use Figure 76 to determine the electrical angle at the rising edge Z. This is the Encoder Marker Electrical Angle.

$$EMA = 90^\circ + \left( tz \frac{180}{t1} \right)$$

Where:

EMA = Motor Encoder Marker Angle

If EMA is >360° subtract 360°.

Many encoders are designed so that the encoder marker pulse occurs a specified number of electrical degrees from the rising edge of U. You could obtain this value from the encoder specification sheet however, to minimize errors in conversion, you should make this measurement.

If you cannot obtain a stable angle measurement between U or Z and  $V_{TS}$ , check the encoder to verify it has the proper cycles per revolution for your motors pole count.

## CW Reference Rotation

If the reference motion for the encoder is CW (i.e., Encoder Reference Motion parameter will be set to 1), rotate the motor in the CW direction. Using an oscilloscope, look at the phase relationship between the rising edge of U and negative peak of

$V_{TS}$ . Use the figure below to determine the electrical angle at the rising edge of U. Determine the marker electrical angle in a similar manner.

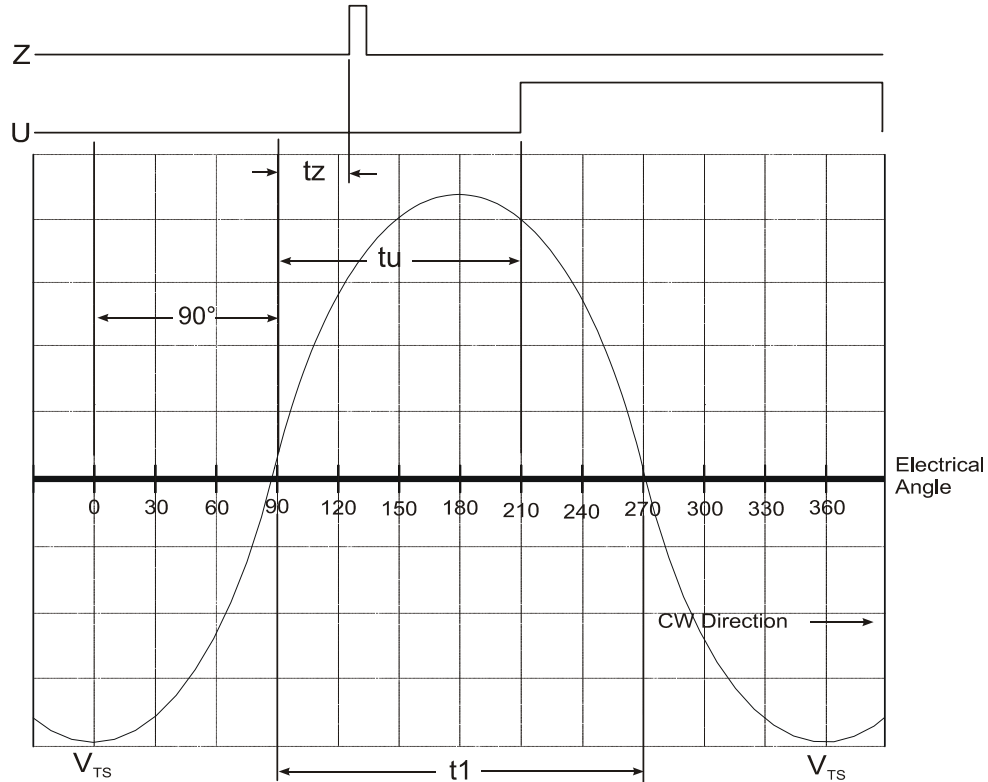


Figure 113: CW Electrical Angle Plot

In Figure 76 the electrical angle decreases from left to right and the positive peak of  $V_{TS}$  occurs at zero degrees electrical. In Figure 77 the electrical angle increases from left to right and the negative peak of  $V_{TS}$  occurs at zero degrees electrical. Note that with a CW reference rotation the negative peak of  $V_{TS}$  is at zero electrical degrees and the electrical angle decreases from left to right.

**Note**

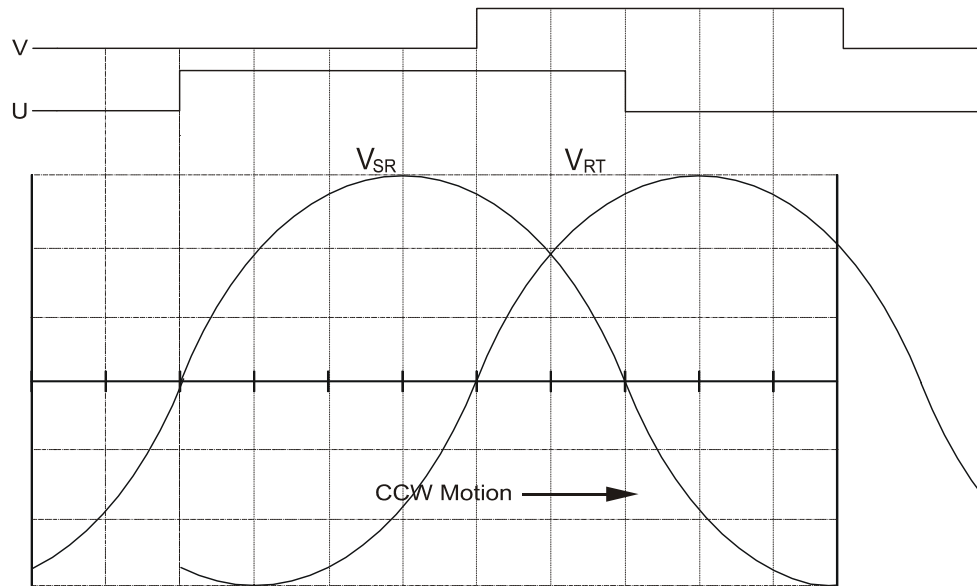
If you cannot obtain a stable angle measurement between U or Z and  $V_{TS}$ , check the encoder to verify it has the proper cycles per revolution for your motor's pole count.

**Establishing a Standard Alignment**

A typical encoder alignment practice is to set the rising edge of U to zero crossing of the rising wave of  $V_{SR}$  with the motor rotating CCW.

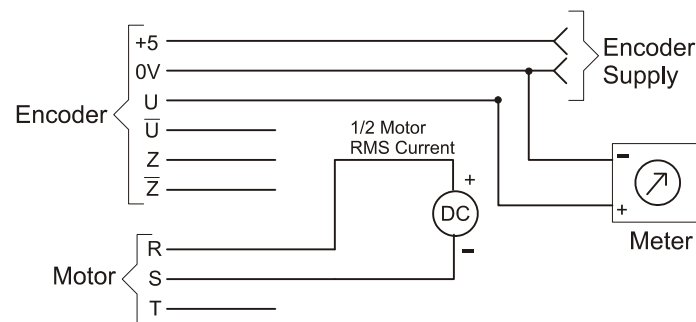
**Dynamic Alignment Method**

This method is used at Control Techniques to establish the alignment on motors. It is accomplished by spinning the motor CCW with another device while monitoring U and  $V_{SR}$ . Then while the motor is spinning CCW, the encoder body is rotated on its mounting until the desired alignment is established. The encoder is then locked down. This will cause the rising edge of V to line up with the rising edge zero crossing of  $V_{RT}$  when the encoder reference rotation is CCW.



### Static Alignment Method

Another method to align the encoder is to apply DC current through the motor power phases R to S and rotate the encoder on its mounting until the rising edge of U is detected with a voltmeter or an oscilloscope. This procedure does not require spinning the motor.



The current applied through R to S should be the same polarity each time (i.e., + on R) and the current must be controlled to no more than 50 percent of the RMS stall current rating of the motor.

### Note

Verify that you are seeing the rising edge of the U channel in the encoder reference direction by twisting the motor shaft CCW by hand while the DC current is applied and verifying that U goes high when the shaft is rotated in the encoder reference direction.

## Step 4: Determine Motor Parameters

Measuring the actual motor  $K_e$  is recommended because not all motor manufacturers use the same measurement techniques. Normally the number of motor poles and the  $K_e$  is specified on the motor data sheet. If it not, or you wish to verify it, use the following tests.

### Motor $K_e$

In this test you will be measuring the AC voltage generated by the motor or the CEMF (Counter Electro-Motive Force). This measurement requires an AC voltmeter that can accurately read sine waves of any frequency and some way to determine the motor speed at the time of the measurement, such as a photo tachometer or an oscilloscope.

1. Connect the volt meter across any two of the motor power leads.
2. Set the volt meter to read VAC at its highest range. You can usually expect to read about 20 to 300 VAC.
3. Spin the motor in either direction at least 500 RPM.

- Determine the actual RPM using a photo-tachometer or by monitoring the frequency of the Z channel with an oscilloscope.

---

**Note**

When using an oscilloscope, use the following formula to determine the motor velocity in RPM.

---

$$\text{RPM} = \frac{60}{\text{Seconds/Revolutions}}$$

Use the following formula to determine the Ke of the motor after the voltage and speed measurements.

$$\text{Ke} = 1000 \frac{\text{VRMS}}{\text{RPM}}$$

**Motor Pole Count**

To determine the number motor poles, measure the number of electrical revolutions per mechanical motor revolution. The number of poles in the motor is two times the number of electrical cycles (360 degrees) per mechanical revolution. Use the following procedure:

- Attach a scope probe to the R winding referenced to the S winding and one to the encoder Z channel referenced to the encoder power supply 0 volt.
- Connect S winding to the encoder power supply 0 volt wire thereby connecting the scope ground clips together.
- Set the scope up to trigger on the Z channel.
- Rotate the motor in either direction at any speed.

---

**Note**

If you are using an electric drill to rotate the motor, the drill's name plate should specify the maximum RPM.

---

- Adjust the horizontal time base until at least two Z channel pulses are visible.
- Count the number of full cycles of the Motor waveform you see between the rising edges of the Z pulses.
- Calculate the number of motor poles:

$$\text{Number of Cycles} \bullet 2 = \text{Number of Motor Poles}$$

**Step 5:Editing the MOTOR.DDF File**

The PowerTools Pro software obtains the names and parameters of user defined motors from the Motor Data Definition File (MOTOR.DDF). This file is automatically loaded during the PowerTools Pro installation and is located in the same directory as the PowerTools Pro software. This file contains two sections: the Header and the Motor data. An example MOTOR.DDF file is shown on page 282.

The MOTOR.DDF file is a text file setup that uses carriage returns as parameter separators. It can be accessed and edited with any general purpose text editor such as Windows Notepad. In order for some text editors to read the file and recognize it as a text file, you will need to copy it over to another directory and change the file name suffix from .ddf to .txt.

Most text editors allow you to save the modified file as a text file if it was read originally as a .txt file. You must be careful that the edited file is saved as a text file otherwise it will be unusable as a .ddf file.

After you have completed editing the file, save it as MOTOR.DDF file. Then copy it back to its original directory, overwriting the existing MOTOR.DDF file. The next time PowerTools Pro is started it will automatically recognize the new MOTOR.DDF file.

## Header

The header includes the revision and serial number information along with a count of how many special motor definitions are included in the particular file. Standard Control Techniques motors will not appear in this file because their data is hard coded into the drive's memory.

---

### Revision

---

This parameter is fixed and is set by the PowerTools Pro revision during installation.

---

### Serial

---

This parameter defines the format of the .ddf file. Do not change this parameter.

---

### Beta

---

This parameter is not used and should be set to 0.

---

### NameCount

---

The NameCount parameter defines the number of motor sections contained in the .ddf file. If four motor sections exist, this parameter should be set equal to 4 which will cause PowerTools Pro to recognize only the first four (4) motor definitions in the file.

## Motor Data

The motor data section contains the names and parameters of one or more user defined motors.

MotorID is used for each motor to mark the beginning of a new user defined motor definition. The format is [MotorXX] where XX is the ID number starting with zero and incrementing by one.

You must use both ID numbers. For example, an ID of 1 would be entered as 01. There is no practical limit to the number of user defined motors allowed in the .ddf file. Only one set of user defined motor data can be stored in a single drive at any one time.

The motor name is limited to 12 characters and must immediately follow the MotorID marker. This is the motor name that shows up in the "Motor Type" combo box in PowerTools Pro. The motor parameters do not define with which drive they may be used. Therefore, any user defined motor may be used with any drive.

```
[Definition]
revision=0x4132
serial=1000
beta=0
nameCount=2

[Motor0]
name=User1
motorPoles=4
encoderLines=2048
encoderMarker=330
encoderU=330
encoderRef=0
rotorInertia=0.00010
motorKE=28.3
phaseResistance=20.80
phaseInductance=27.1
peakCurrent=4.29
continuousCurrent=1.43
maxOperatingSpeed=5000

[Motor1]
name=User2
motorPoles=4
encoderLines=2048
```

```

encoderMarker=330
encoderU=330
encoderRef=0
rotorInertia=0.00017
motorKE=28.3
phaseResistance=7.30
phaseInductance=12.5
peakCurrent=7.80
continuousCurrent=2.60
maxOperatingSpeed=5000

```

In this example, the parameters of two user defined motors are named “User1” and “User2”. Abbreviated parameter identifiers are used in the .ddf file. The table below shows the abbreviated identifier for each parameter followed by a description of each.

Motor Parameter	DDF Identifier
Motor Poles	motorPoles
Motor Encoder Lines Per Revolution	encoderLines
Motor Encoder Marker Angle	encoderMarker
Motor Encoder U Angle	encoderU
Motor Encoder Reference Motion	encoderRef
Motor Inertia	rotorInertia
Motor KE	motorKE
Motor Resistance	phaseResistance
Motor Inductance	phaseInductance
Motor Peak Current	peakCurrent
Motor Continuous Current	continuousCurrent
Motor Maximum Operating Speed	maxOperatingSpeed

## Motor Parameter Descriptions

### Note

These parameters are valid and active only when a user defined motor is selected. When a Control Techniques motor is selected, the data in these registers remain at the last value set and do not update to reflect the data of the Control Techniques motor selected.

### Motor Poles

Specifies the number of magnetic pole pairs (N-S) on the motor. The supported values are 2, 4, 6, 8, 10, 12, 14 and 16 poles.

### Motor Encoder Lines Per Revolution

Specifies the number of encoder lines per mechanical revolution. The supported values are 1000, 1024, 2000, 2048, 2500, 4096 and 8192. The number of “encoder counts” per revolution is 4 times the value specified here because quadrature decoding is used.

This parameter is used both for commutation and for position/ velocity control. To properly commutate the motor, the drive must know the electrical angle (the angle between the motor magnetic field and stator coils).

### Motor Encoder Marker Angle

Specifies the electrical angle at which the marker (Z) pulse occurs with reference to  $V_{TS}$  when the motor is spun in the encoder reference direction. At power-up the drive obtains an initial estimate of the electrical angle from the status of the U, V and W commutation tracks. This estimate can be off by as much as 30°.

When the drive receives the marker pulse, the drive will, within one second, gradually shift the commutation to the more accurate electrical angle specified by this parameter. The system will then operate more efficiently. See “Step 3: Determine Encoder Alignment” for a detailed procedure on how to determine this parameter.

---

**Motor Encoder U Angle**

---

Specifies the electrical angle at which the rising edge of the U commutation track will occur with reference to  $V_{TS}$  when the motor is spun in the encoder reference direction.

At power-up the drive looks at the status of the U, V and W commutation tracks and, using this parameter, obtains a crude ( $\pm 30^\circ$ ) estimate of the electrical angle. See “Step 3: Determine Encoder Alignment” for a detailed procedure on how to determine this parameter.

---

**Motor Encoder Reference Motion**

---

Specifies the direction of motion assumed in phase plots of the encoder’s quadrature and summation signals. The supported values are CW(1) and CCW(0). Your encoder may have the same phase plot but is generated from a different direction of rotation. This parameter affects the way the drive interprets the quadrature and commutation signals.

---

**Motor Inertia**

---

This parameter specifies the inertia of the motor. The range is .00001 to .5 lb-in-sec<sup>2</sup>. The drive uses this parameter to interpret the “Inertia Ratio” parameter. “Inertia Ratio” is specified as a ratio of load to motor inertia.

---

**Motor KE**

---

Specifies the Ke of the motor. The units are VRMS/kRPM. The line-to-line voltage will have this RMS value when the motor is rotated at 1000 RPM. The range is 5 to 500.

---

**Motor Resistance**

---

Specifies the phase-to-phase resistance of the motor. You can determine this value by measuring the resistance between any two motor stator terminals with an ohm meter. The range is .1 to 50 ohms.

---

**Motor Inductance**

---

Specifies the phase-to-phase inductance of the motor. The range is 1.0 to 100.0 mH.

---

**Motor Peak Current**

---

Specifies the peak current allowed by the motor. The range is 1 to 100 ARMS. If the peak current of the motor is greater than 30 ARMS, specify the peak as 30 ARMS. The drive will limit the peak current to the drive’s capacity.

---

**Motor Continuous Current**

---

Specifies the continuous current allowed by the motor. It is used to determine the current foldback point and the amount of current allowed during foldback. The drive can also limit the continuous current to the motor based on the drive capacity. This means that the operational “continuous current” may be different than the value specified here. The range is 1 to 100 ARMS.

---

**Motor Maximum Operating Speed**

---

Specifies the maximum operating speed of the motor. It is used by the drive to set the default motor overspeed trip point and to limit the Velocity Command. The Velocity Command is limited to 9/8ths (112.5 percent) of the Motor Maximum Operating Speed. If the actual velocity exceeds 150 percent of this value, the drive will fault on Overspeed. Typically this parameter is determined by the encoder bandwidth and/or other mechanical or electrical parameters of the motor. The maximum value is 11,000 RPM.

## Step 6:Configuring the Drive

Once you have determined the motor parameters and entered them into the MOTOR.DDF file, you can configured the drive to the user defined motor using PowerTools Pro software. Once PowerTools Pro is started it will read the MOTOR.DDF file and you will be able to select the non-Control-Techniques motor.

## Selecting a User Defined Motor

Use the following procedure to select the user defined motor with PowerTools Pro.

1. Start PowerTools Pro and either open an existing file or start a new file offline.

---

### Note

PowerTools Pro will not allow you to select a “Motor Type” or “Drive Type” while online with a drive.

---

2. From the “Motor Type” list box on the EZ Setup tab (or from the Motor tab if you are in Detailed Setup view) select your motor from the list of motors.

When you select a new motor, PowerTools Pro will display the Motor Parameters dialog box. In most cases you will want to select the default option which sets the Full Scale Velocity parameter to the value you entered into the MOTOR.DDF file.

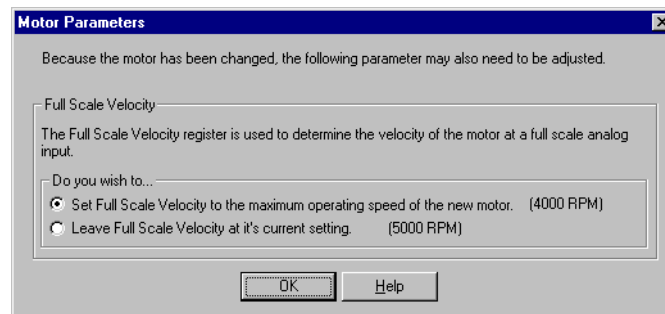


Figure 114: Motor Parameters Dialog Box

3. Select the correct drive type.
4. Download the configuration to the drive.
5. Select the *OK* button.

The drive will now be configured for the non-Control-Techniques motor.

## Step 7: Verification and Checkout

Once the cabling and interface circuitry have been assembled and the drive has been correctly configured, you are ready to power-up the drive. Use the procedure below to power-up the servo system and verify that it is operating correctly.

---

### Note

For safety reasons, it is a good idea to double check that the key motor parameters below have been specified correctly.

---

- Motor Ke
- Motor Resistance
- Motor Inductance
- Motor Peak Current
- Motor Continuous Current

This procedure requires the use of PowerTools Pro and some kind of I/O simulator. The simulator is needed to generate a variable analog command voltage and to allow the drive to be enabled and disabled. It is possible that the motor will “run-away” during the course of the test.



The motor may run away during this test. Make sure it is securely fastened and that there is nothing connected to the motor shaft.

---



At a certain point in the test it will be necessary to manually rotate the motor through an integral number of revolutions. This can only be done if the motor shaft and housing are marked in some way so that the motor can be aligned to a specific position. A disk or pulley can be installed during that portion of the test to make this alignment more precise.

The four tests are Rotation test, Torque test, Commutation test and Velocity test. Each test builds on the last. It is important to perform the tests in the order given.

---

## Note

Do not attempt to perform a test if you were not able to get the proceeding test to work.

---

## Rotation Test

This test verifies that the encoder has been correctly interfaced to the drive.

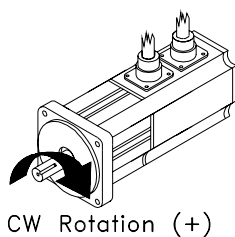


Figure 115: CW Rotation of the Motor

---

## Note

This test assumes that you have completed “Step 6: Configuring the Drive” on page 287.

---

1. Power-up the drive but leave it disabled.
2. While online with the drive, select the Status view. Find the Position Feedback parameter and note its value.
3. Mark the motor shaft and the motor face. This is your reference starting point.
4. Manually rotate the motor CW one revolution as accurately as you can. Verify that the Position Feedback increased by one revolution. This verifies that the A and B encoder signals are wired correctly and the Motor Encoder Reference Motion parameter is correct.
5. Manually rotate the motor as accurately as you can, CW 20 revolutions. The Position Feedback should increase by exactly 20 revs. If the change has some significant fractional part (20.5 for example) the Motor Encoder Lines Per Revolution parameter is probably wrong.
6. Select “View Motor Parameters” from the **Tools** menu. Note the value of the Commutation Track Angle parameter. This parameter is obtained directly from the state of the U, V and W commutation tracks.
7. Slowly rotate the motor clockwise. The Commutation Track Angle should increase in 60 degree steps and will roll over to 0 at 360. If it does not change, there is a fundamental problem with the U, V and W encoder signals. If it decreases or changes erratically there is either a problem with the Motor Encoder Reference Motion parameter or the phasing of U, V and W.
8. Disconnect serial communications by clicking on the *Disconnect* button.
9. Power-down the drive and wait for the status display to go blank and then power the drive up again.
10. Re-establish communications with the drive by selecting the *Upload* button.
11. Select “View Motor Parameters” from the **Tools** menu. Note the value of the Commutation Angle Correction parameter. Its value should be zero until the motor encoder Z channel is detected. Rotate the motor through one or more complete revolutions until the Z channel is detected.
12. The value should now have a non-zero value between  $\pm 40$  degrees. If the parameter is still zero, the drive is probably not seeing the marker pulse.

To confirm this repeat Steps 7-9 several times with different motor shaft starting locations. If the absolute value of the parameter is greater than 40, there is either a problem with the phasing of U, V and W or an inconsistency in the encoder alignment parameters.

## Torque Test

The purpose of this test is to enable the drive in Torque mode and verify that a positive command produces CW torque.

1. Use PowerTools Pro to select Torque mode and set Full Scale Torque to 5 percent. Then click the *Update* button to download the changes to the drive.

With Full Scale Torque set to 5 percent, a maximum analog command of 10 volts will generate 5 percent of continuous torque in the motor which should be enough to spin the motor but not to damage it.

2. Move to the Analog view and find the “Analog Input” parameter.
3. Using your simulator adjust the analog command until the value of this parameter is approximately 0 volts.
4. Enable the drive. It should not move. If the drive faults at this point you most likely have a wiring problem (see “Step 1: Motor Wiring”).
5. Gradually increase the analog command voltage. The motor should start moving with a voltage level somewhere between 2 and 5 volts. Verify that the direction of motion is CW.
6. If there is CCW or no motion, there is a problem with encoder alignment parameters. If the motor moves 30 to 90 ° and then stops, there could be one of several problems:
  - The number of Motor Poles has been specified incorrectly.
  - The Encoder Lines Per Revolution parameter has been specified incorrectly
  - The motor terminals have been mis-identified (see “Step 1: Motor Wiring”).

## Commutation Accuracy Test

This test will determine how accurately the encoder Z channel has been specified. It requires that the motor be connected and ready to run but it will be spun by the drill motor while in Torque mode with a zero torque command.

1. Disable the drive.
2. Set the Torque Limit to 0.
3. Make the Torque Limit input function always active.
4. Enable the drive.
5. Select “View Motor Parameters” from the **Tools** menu so you can monitor the Commutation Voltage.
6. Spin the motor clockwise 500 to 1000 RPM, then counter-clockwise at the same speed.

The Commutation Voltage should be <10 percent. If the Commutation Voltage is higher than 10 percent, the Motor Encoder Marker Angle was incorrectly specified and should be re-tested.

7. Reset the Torque Limit and the Torque Limit Enable input function to their previous settings.

## Velocity Test

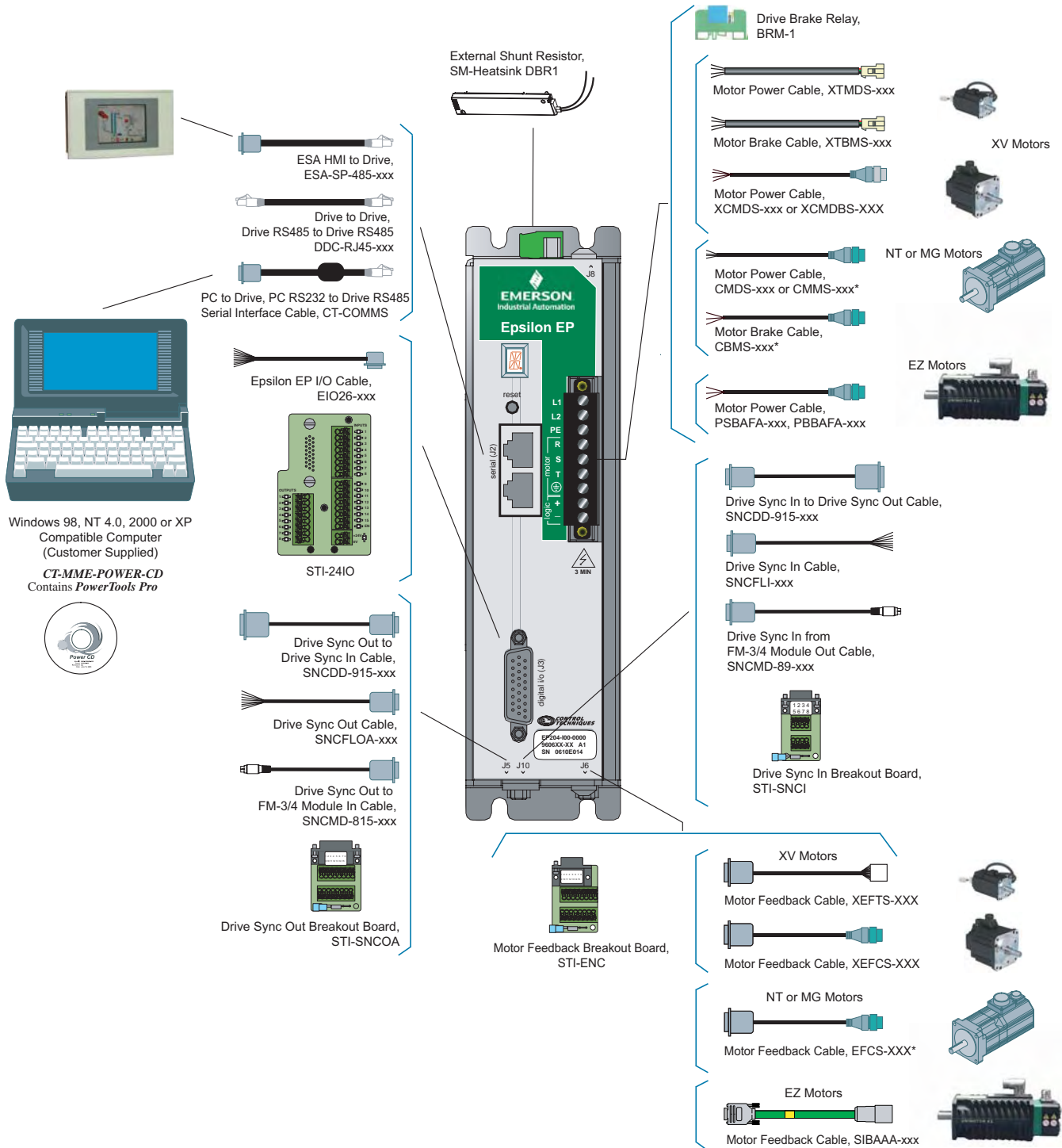
1. Disable the drive.
2. Select Velocity Analog mode and set “Full Scale Velocity” parameter to 12 RPM.
3. Use the simulator to adjust the analog command voltage to 5 volts.
4. Enable the drive. Find the “Velocity Command Analog” parameter on the Status view. Adjust the analog command until this parameter reads exactly 6 RPM. The motor should be moving at 6 RPM. If the system got through the Torque test, the motor should not run-away at this point. If it does, go back and repeat the Torque test.

5. Confirm that the motor velocity is really 6 RPM by confirming that it takes 10 seconds to make one revolution. If this is not the case, the problem may be that both the motor poles and the encoder line density are off by the same factor.
6. Reduce the analog command voltage to zero volts and disable the drive.



# Options and Accessories

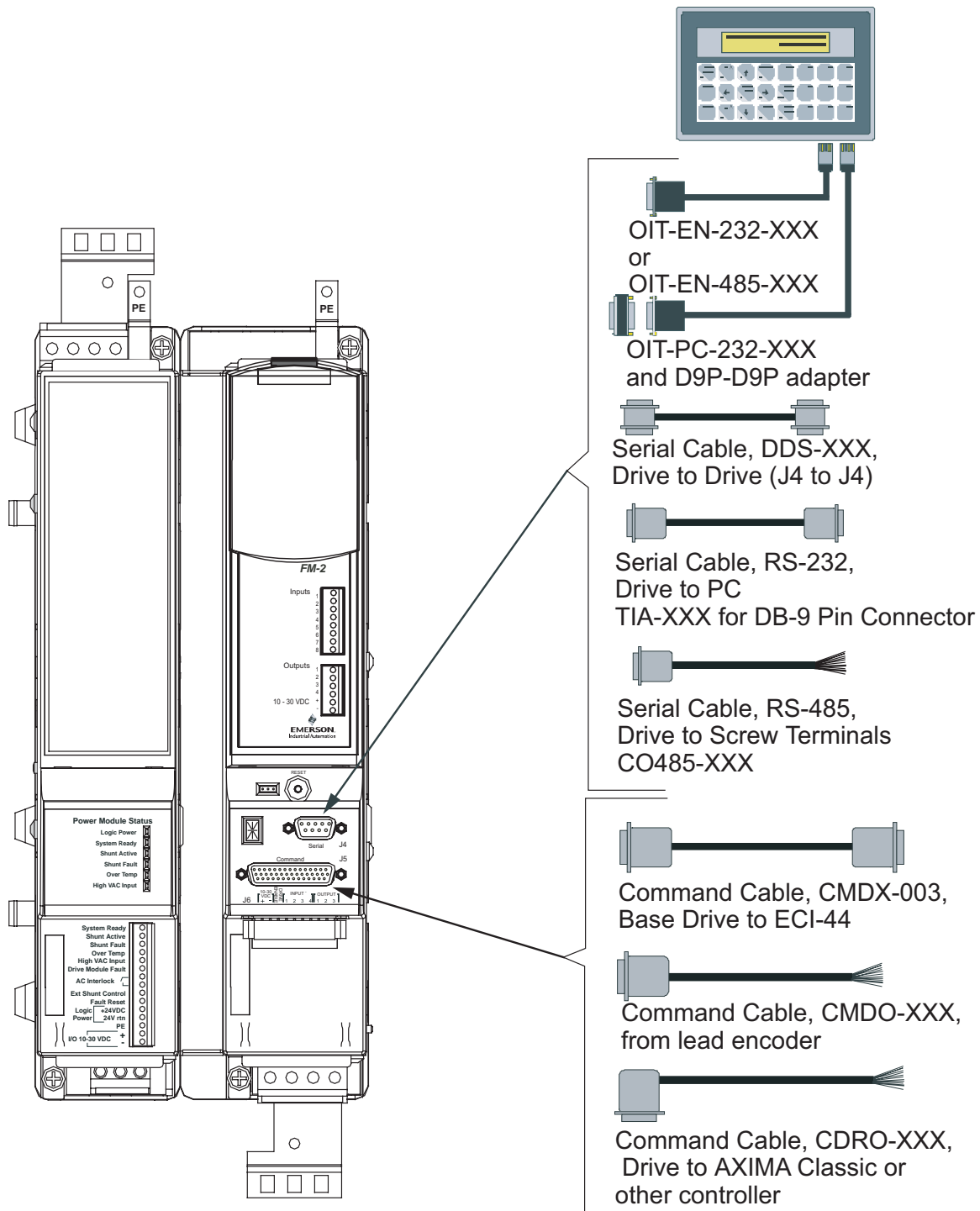
## Epsilon EP Drive Options



\* Flex duty versions of these cables are also available.

## FM-2 Indexing Module Options

The following cables are used to connect various components to the MDS drive module and FM-2.



## STI-24IO Interface

The STI-24IO interface for the Epsilon EP-I drives, see figure 116, allows access to all digital input and output signals. The STI-24IO board mounts directly to the Epsilon EP-I drive Input/Output Connection (J3) and away from any high voltage wiring.

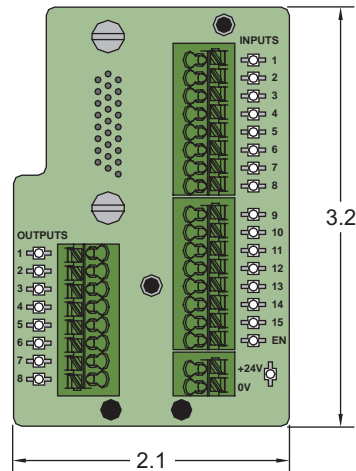


Figure 116: Dimensions of the STI-24IO Board

---

### Note

Wiring should be done with consideration for future troubleshooting and repair. All wiring should be either color coded and/or tagged with industrial wire tabs. Low voltage wiring should be routed away from high voltage wiring.

---

## STI-EIO Interface

The STI-EIO interface for the Epsilon Classic drives, see figure 117, allows access to all digital input and output signals. The STI-EIO board mounts directly to the Epsilon drive's Input/Output Connection (J3) and away from any high voltage wiring.

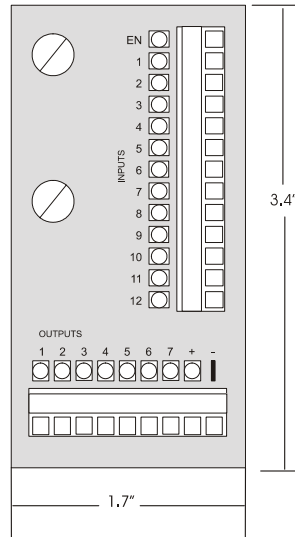


Figure 117: Dimensions of STI-EIO Board

---

### Note

Shield connection points are connected to the shell of the 44-pin "D" connector on the STI-EIO.

---

The STI-EIO wire range is #18 to 24 AWG stranded insulated wire.

---

### Note

Wiring should be done with consideration for future troubleshooting and repair. All wiring should be either color coded and/or tagged with industrial wire tabs. Low voltage wiring should be routed away from high voltage wiring.

---



## ECI-44 External Connector Interface

The ECI-44 allows access to all command and input and output signals on the MDS drive module. The ECI-44 should be mounted close to the drive module and away from any high voltage wiring. The ECI-44 comes complete with the hardware necessary for mounting to most DIN rail mounting tracks.

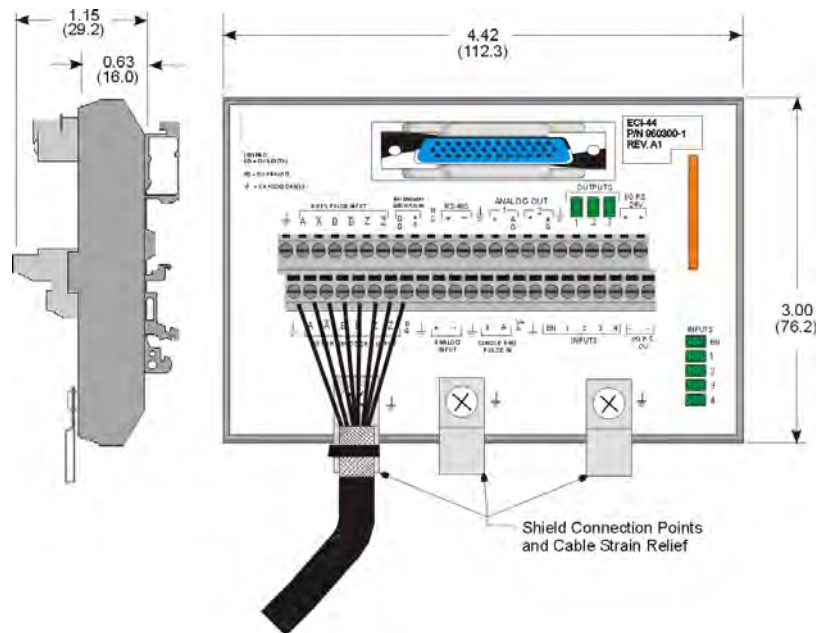


Figure 118: Dimensions of ECI-44

---

### Note

Shield connection points are connected to the shell of the 44-pin “D” connector on the ECI-44.

Use tie wraps to provide a strain relief and a ground connection at the shield connection points.

If you do not wish to use the DIN rail mounting hardware, the ECI-44 can be disassembled and the mounting clips removed.

The ECI-44 wire range is #18 to 24 AWG stranded insulated wire.

---

### Note

Wiring should be done with consideration for future troubleshooting and repair. All wiring should be either color coded and/or tagged with industrial wire tabs. Low voltage wiring should be routed away from high voltage wiring.

---

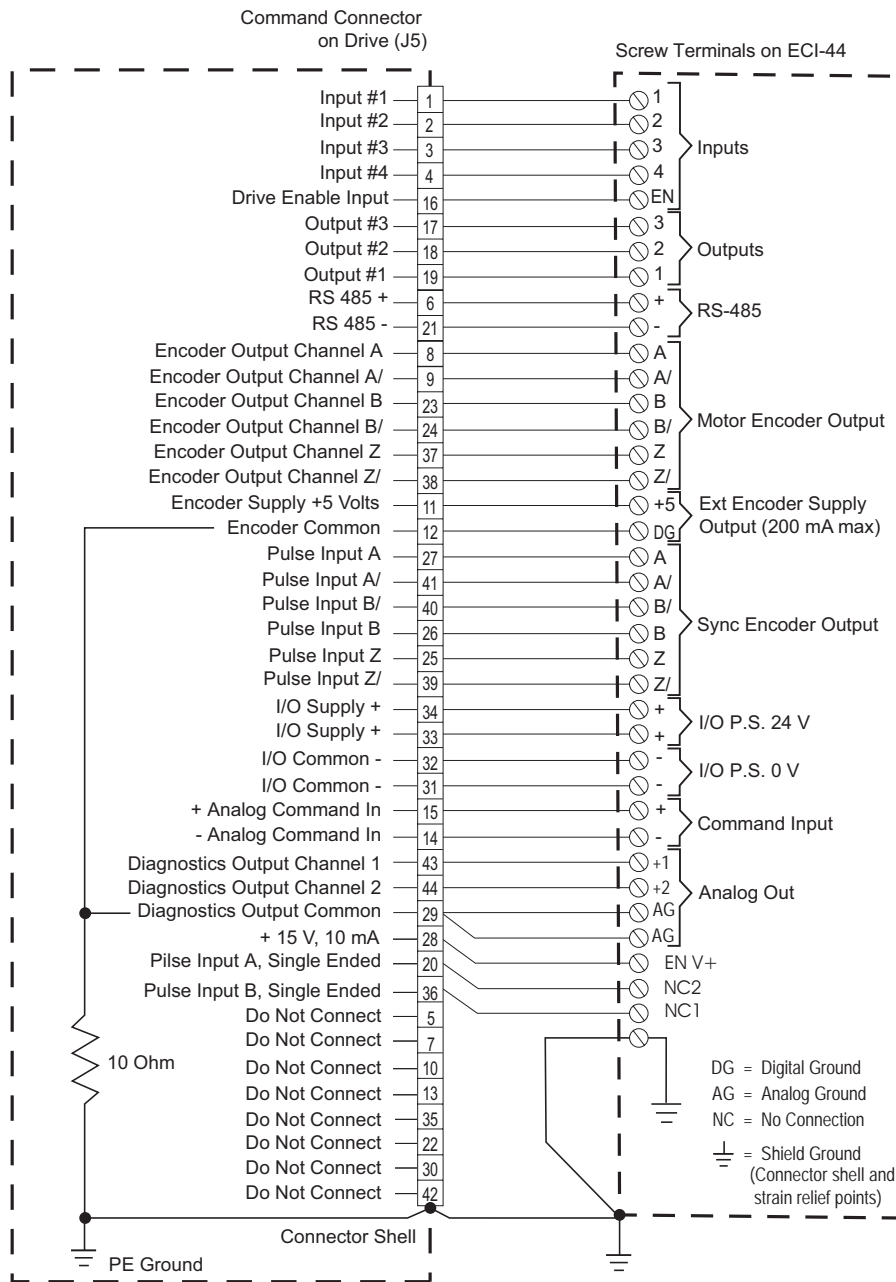


Figure 119: ECI-44 Signal Connections

# Specifications

Drive overload protection.

Rated output current (Amps RMS)		
Drive Model	Continuous	Peak
Ei-202	1.8	3.6
Ei-203	3.0	6.0
Ei-205	5.0	10.0

## FM-2 Specifications

Power consumption: 5 W from the drive module power supply.

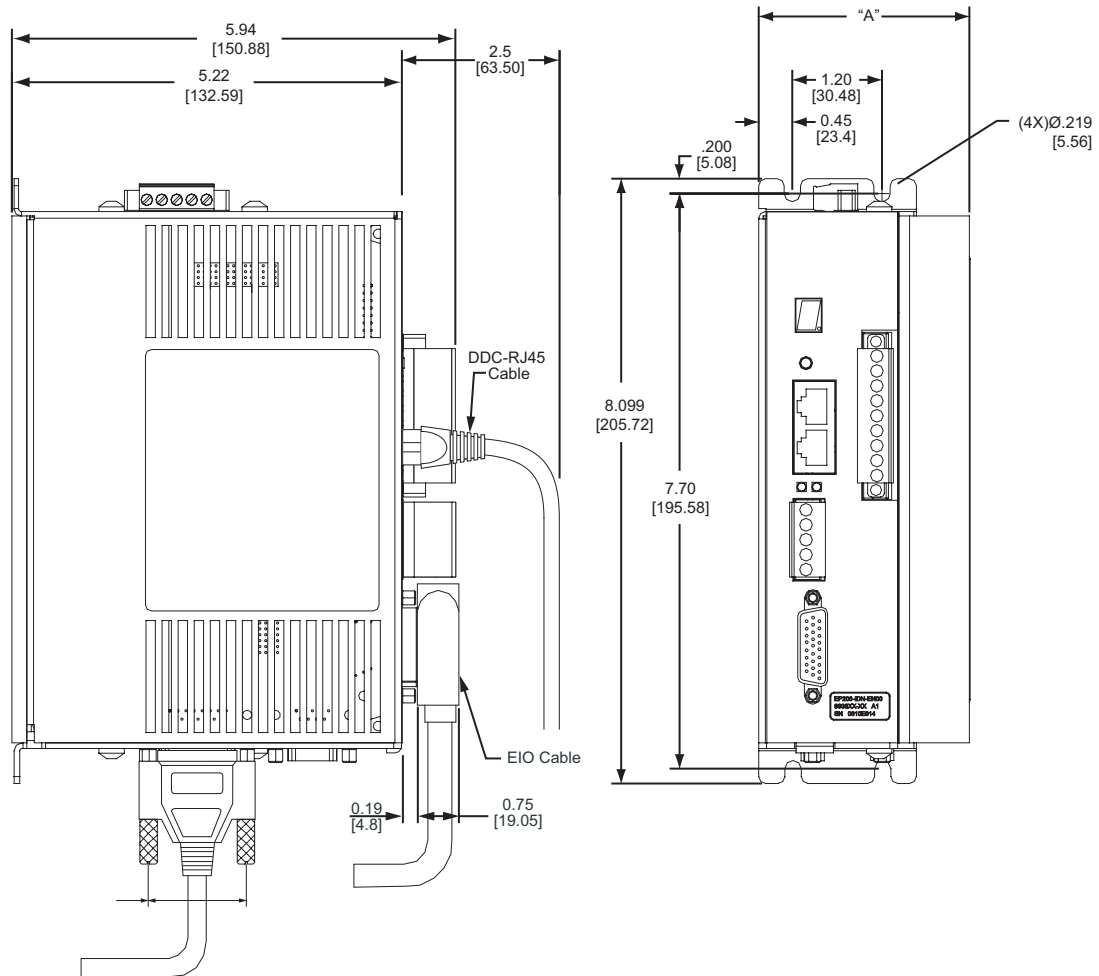
Function	Electrical Characteristics
Inputs	10-30 V ("On"), 0-3 V ("Off"), optically isolated
Outputs	10-30 V, DC sourcing, 150 mA, optically isolated

# Dimensions and Clearances

## Epsilon EP-I Drive

The following table applies to the "A" as shown in the figure below.

Drive Model	Dimension "A" (shown in inches/mm)
EP202/204	2.11 [53.59]
EP206	2.82 [71.63]



# FM-2 Dimensions and Clearances

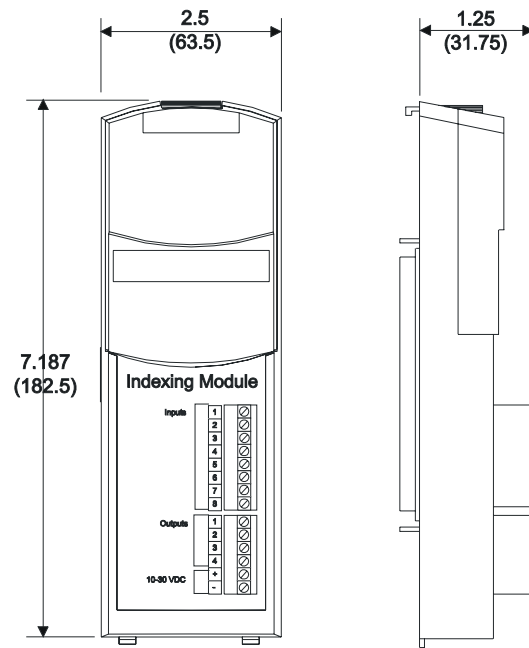


Figure 120: FM-2 Module Dimensions

## Power Dissipation Calculation

Calculating actual dissipation requirements in an application can help minimize enclosure cooling requirements, especially in multi-axis systems. To calculate dissipation in a specific application, use the following formula for each axis and then total them up. This formula is a generalization and will result in a conservative estimate for power losses.

$$TPL = \frac{TRMS \cdot Vmax}{1500} + Pld + Psr$$

Where:

TPL = Total power losses (Watts)  
 TRMS = RMS torque for the application (lb-in)  
 Vmax = Maximum motor speed in application (RPM)  
 Pld = Logic Power Losses Drive (Watts)  
 Psr = Shunt Regulation Losses (Watts)-(RSR-2 losses  
 or equivalent)

---

### Note

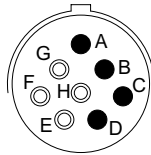
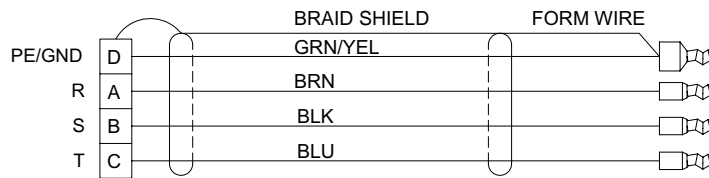
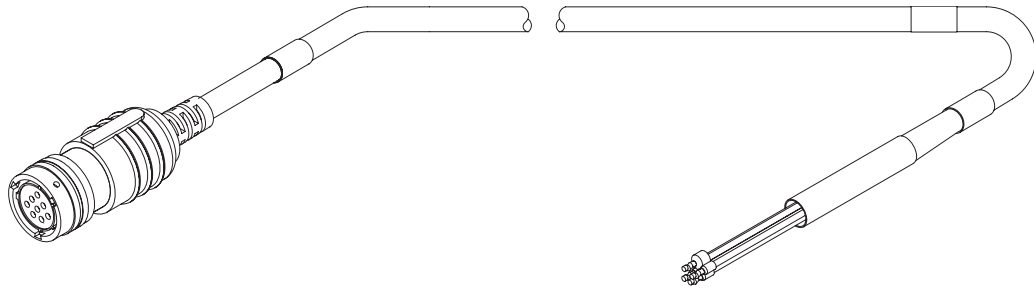
$TRMS * Vmax / 1500 = \text{Power Stage Dissipation} = Pp$

---

A more accurate calculation would include even more specifics such as actual torque delivered at each speed plus actual shunt regulator usage. For help in calculating these, please contact the Application Department at Control Techniques with your system profiles and loads.

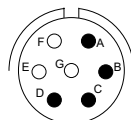
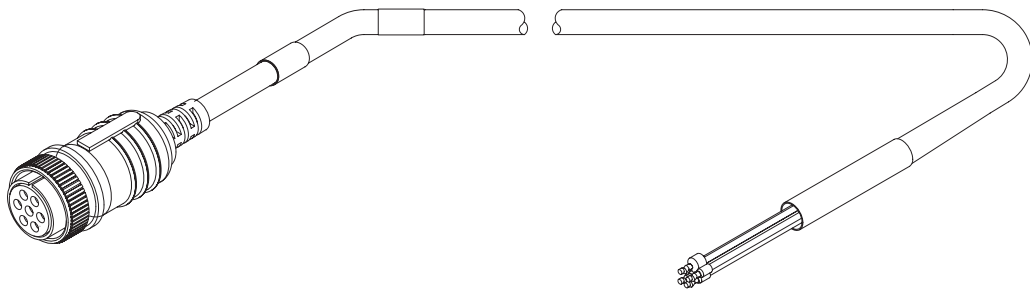
# Cable Diagrams

## CMDS-XXX Cable



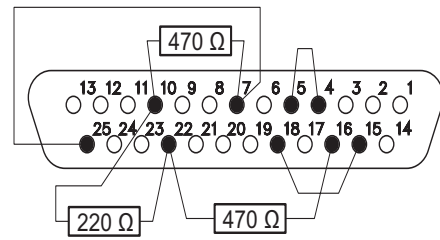
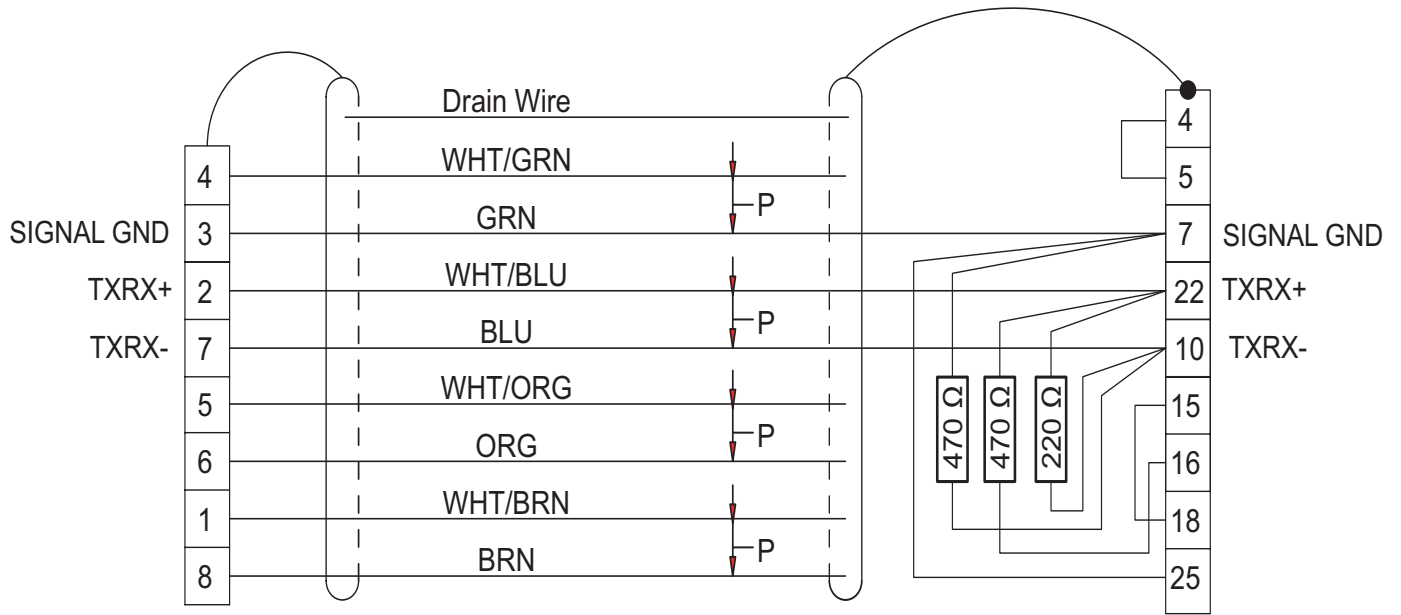
SOLDER SIDE  
Socket

## CMMS-XXX Cable

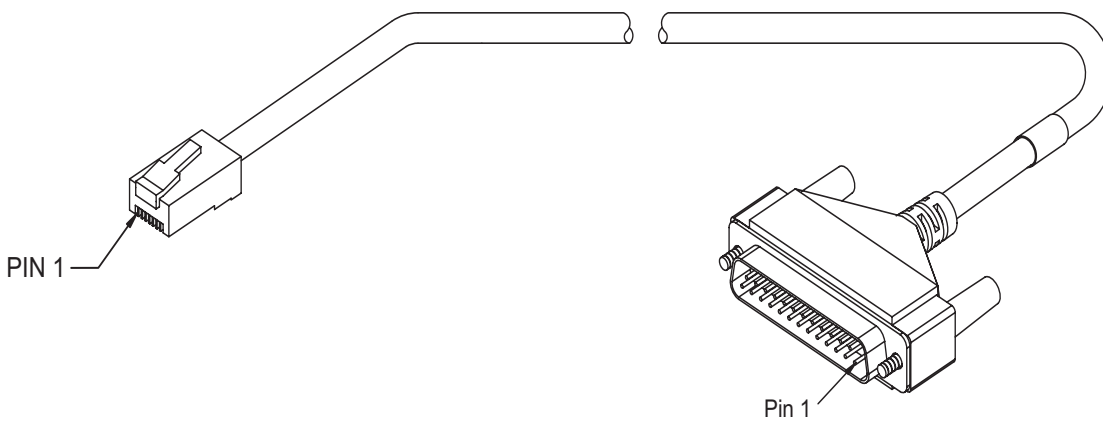


SOLDER SIDE  
Socket

ESA-SP-485

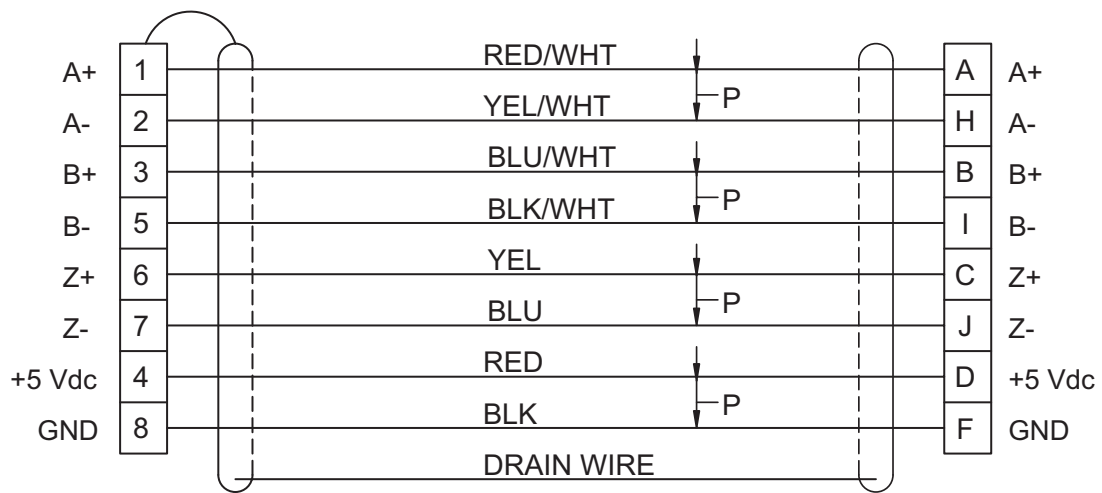
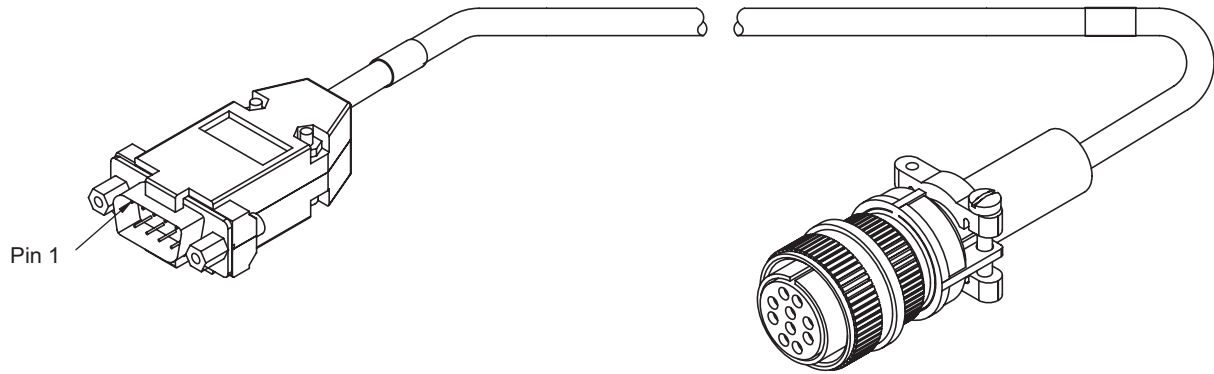


SOLDER SIDE  
Pin

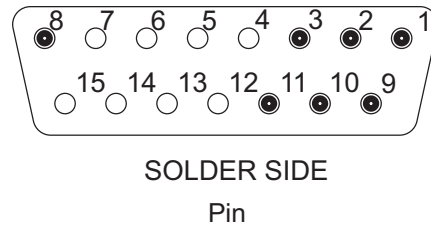
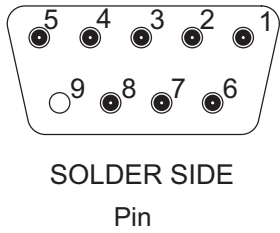
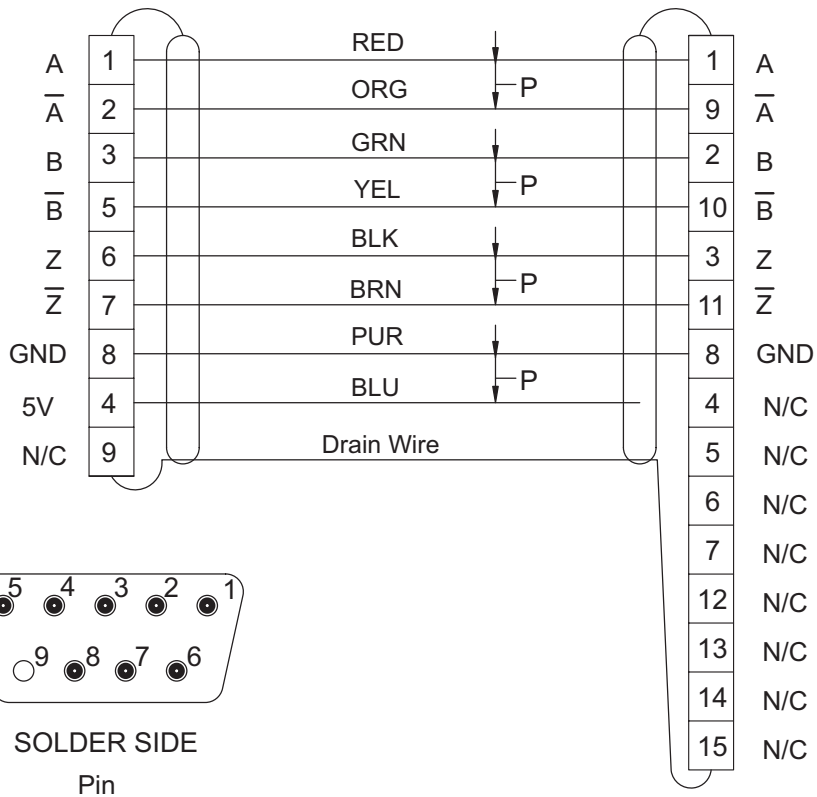
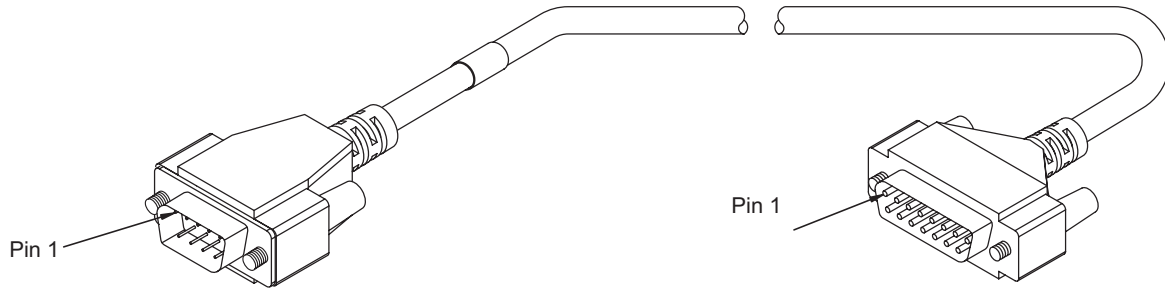




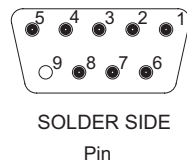
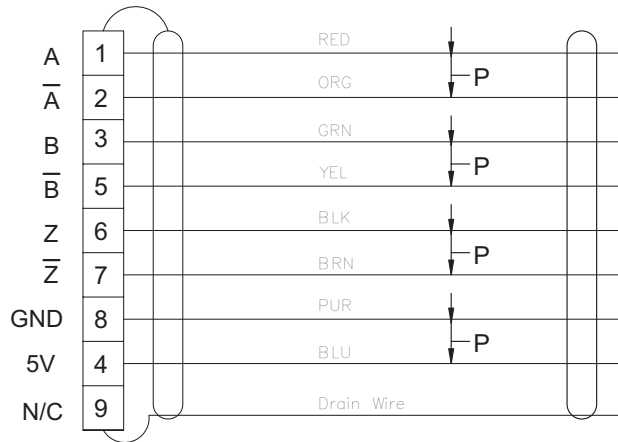
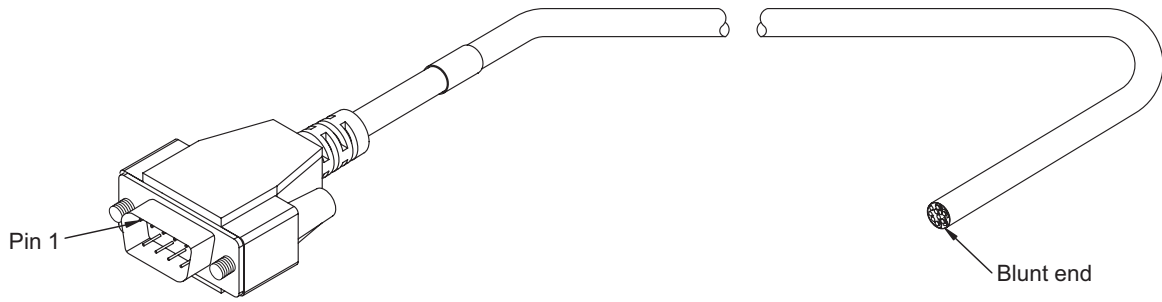
SNCE



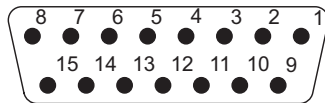
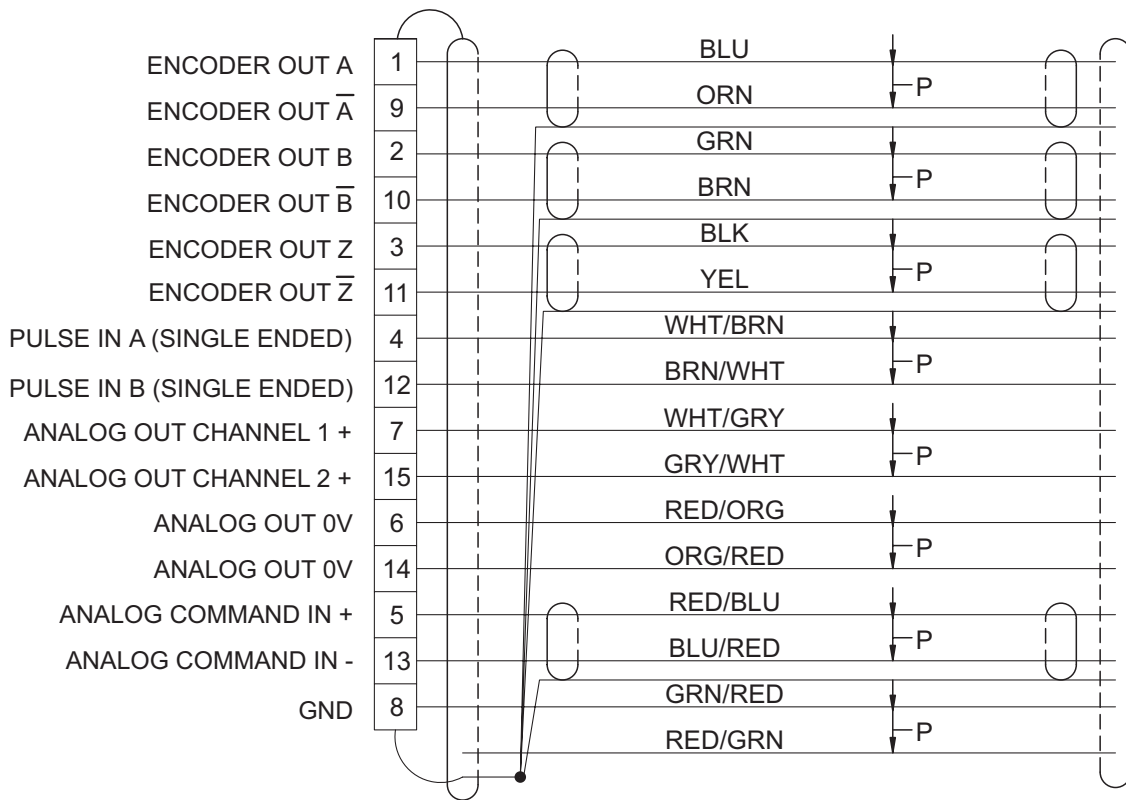
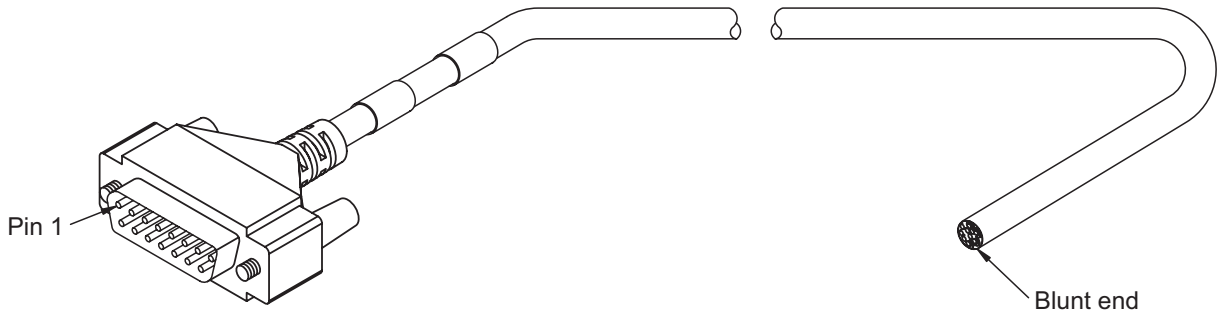
SNCDD-915



SNCFLI



SNCFLOA

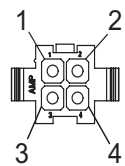
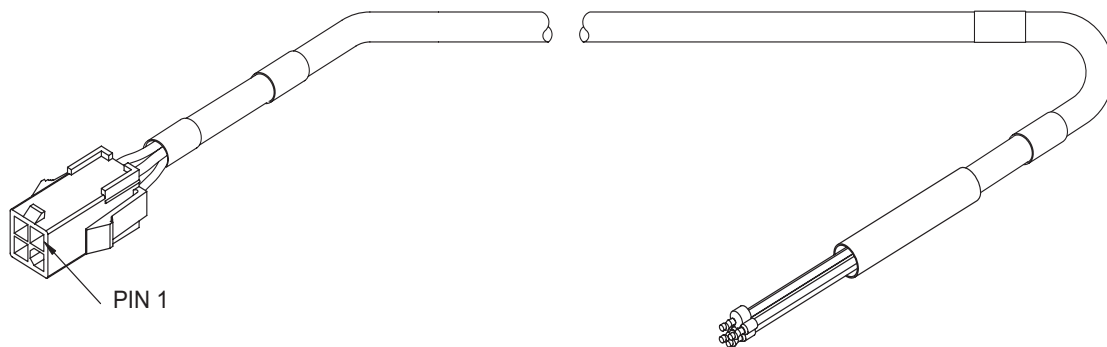


SOLDER SIDE

Pin

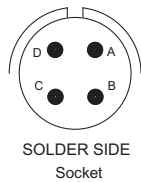
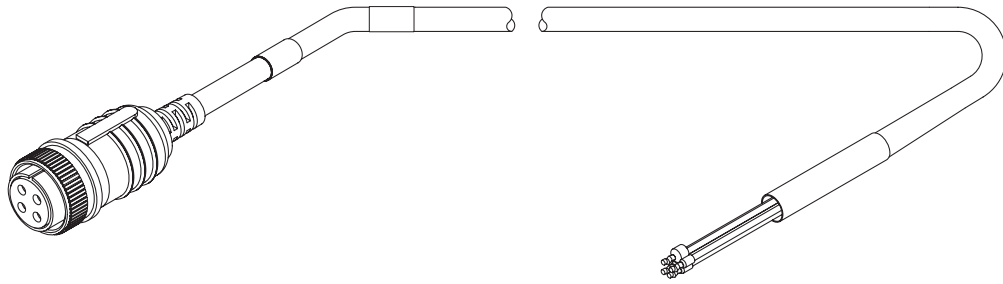
# MOTOR POWER CABLES

## XTMDS

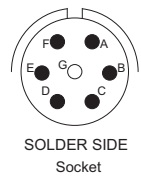
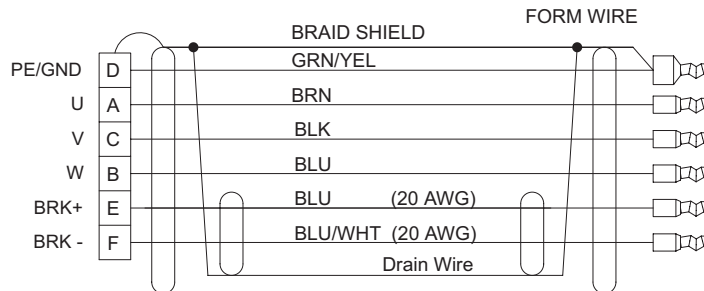
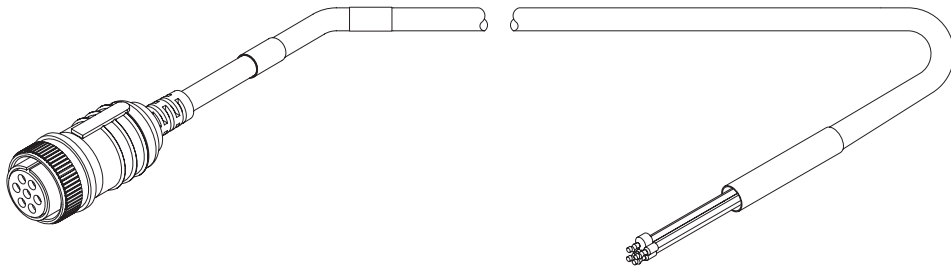


REAR VIEW OF CONNECTOR

XCMDS

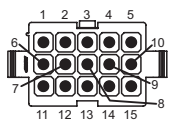
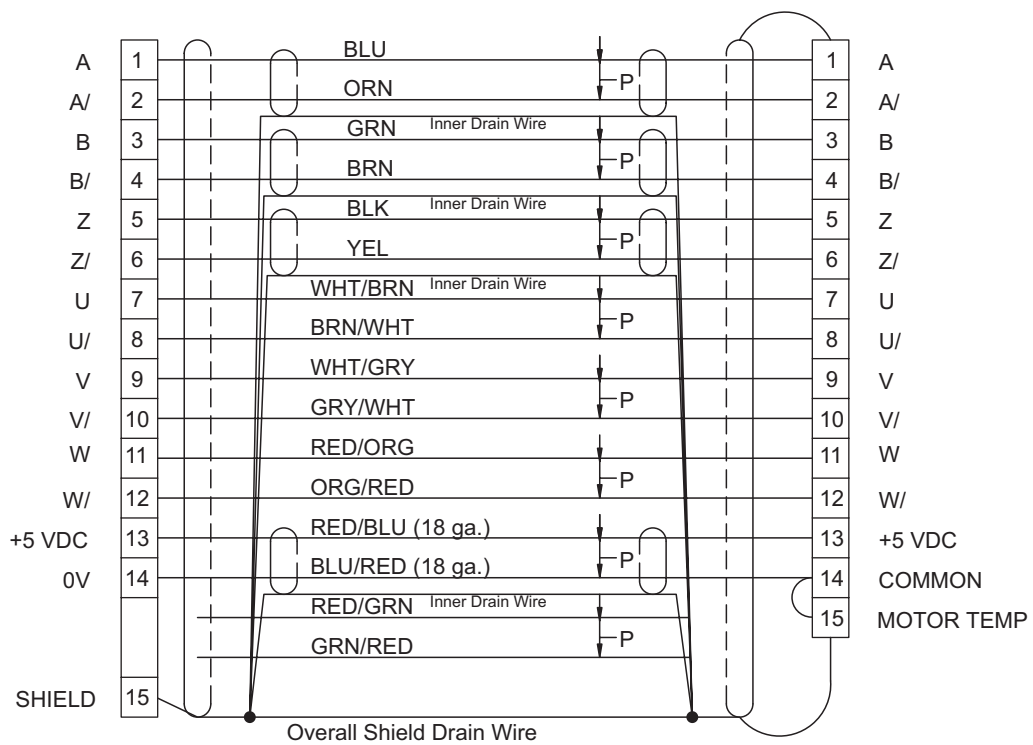
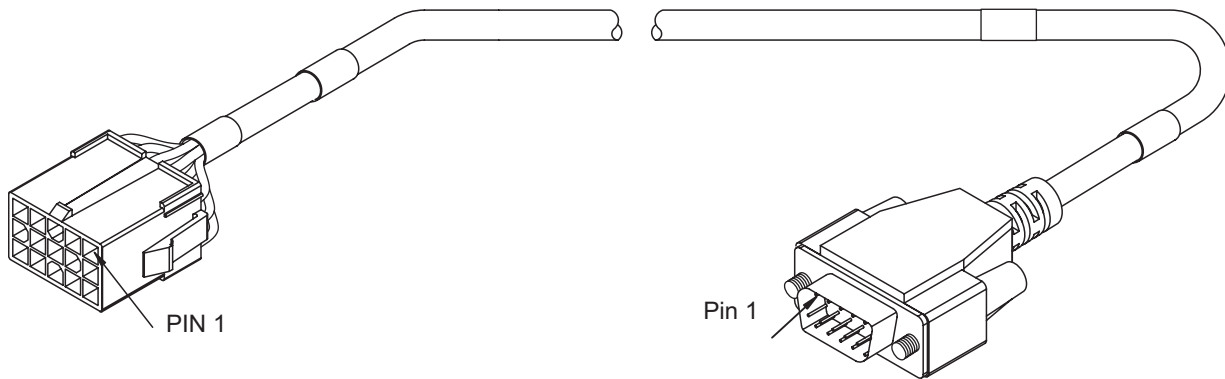


XCMDBS

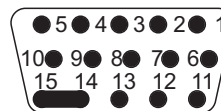


# MOTOR FEEDBACK CABLES

## XEFTS

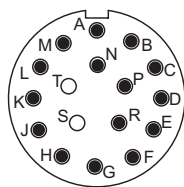
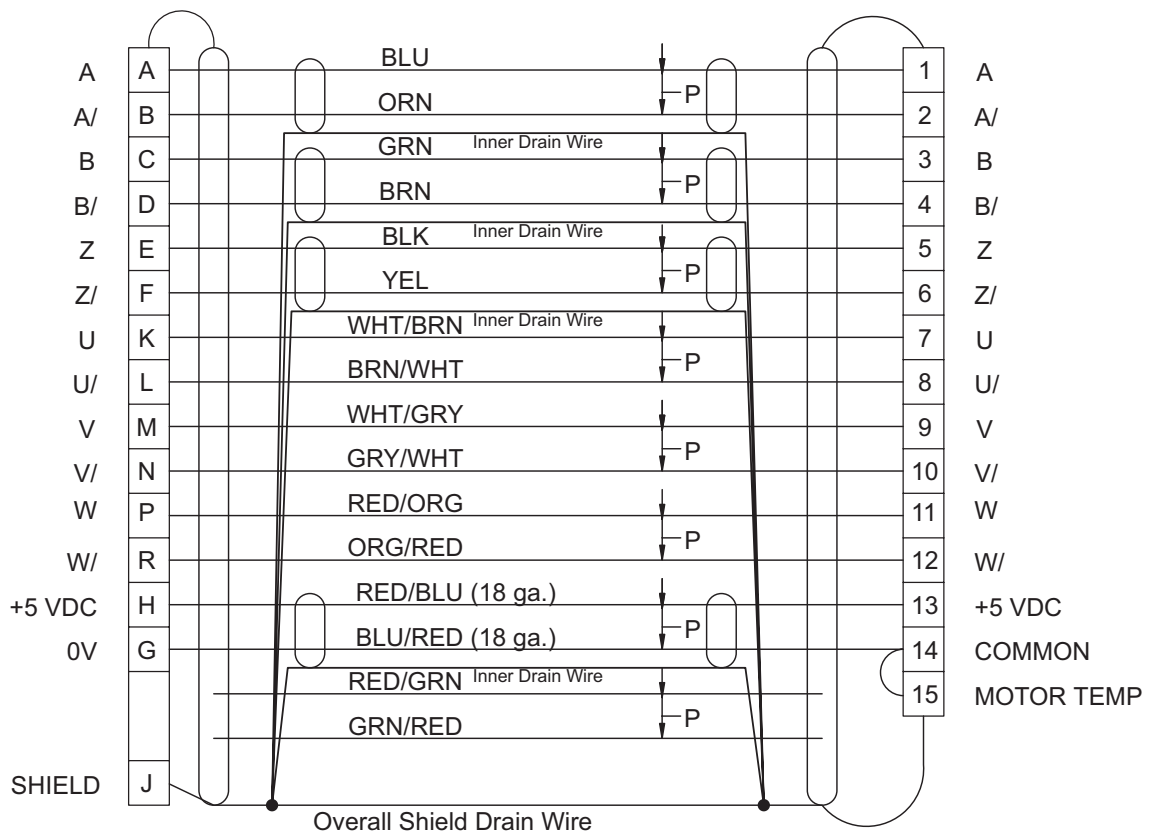
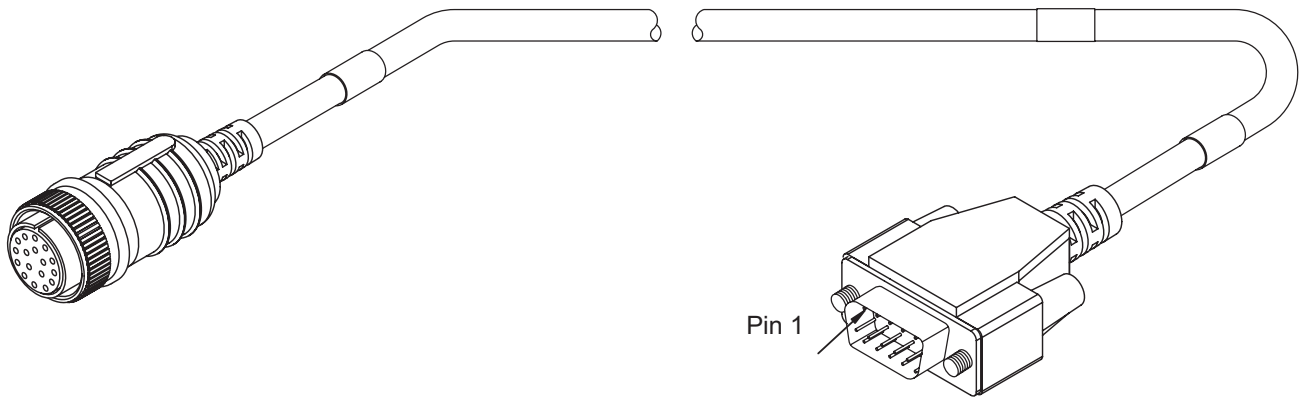


REAR VIEW OF CONNECTOR

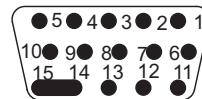


SOLDER SIDE Pin

XEFCS



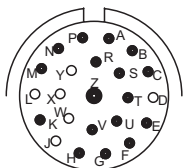
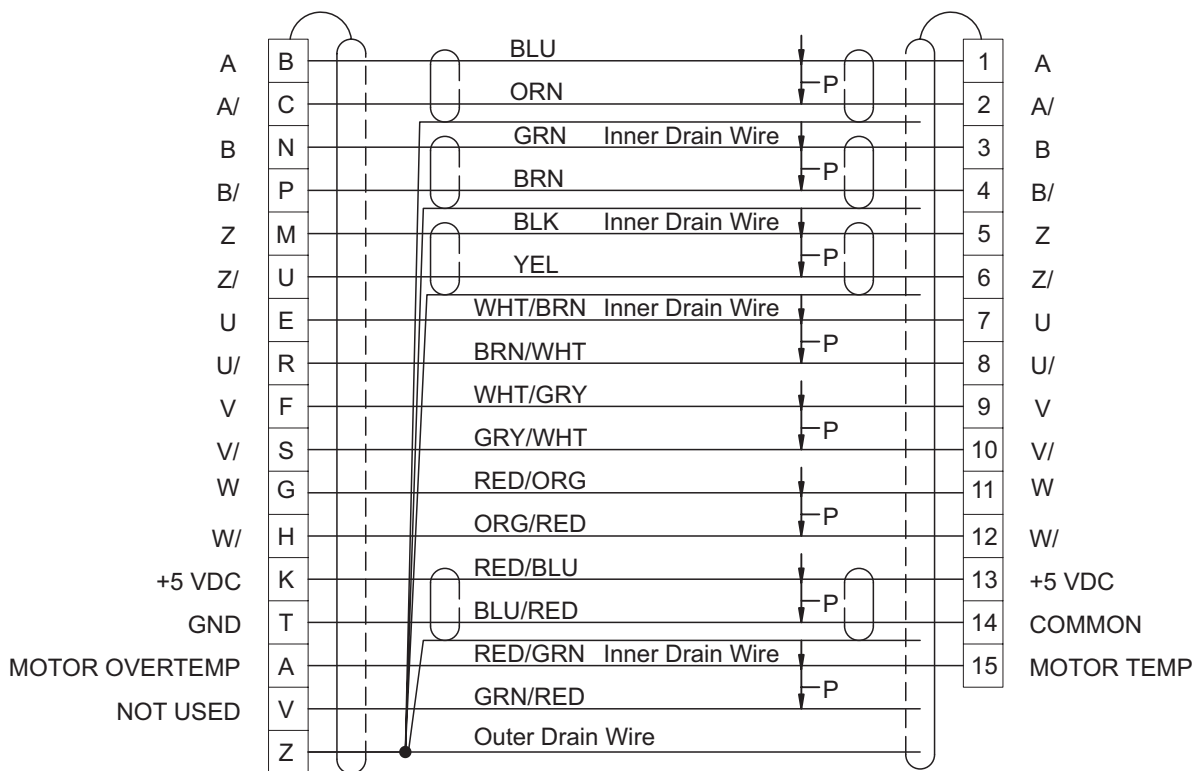
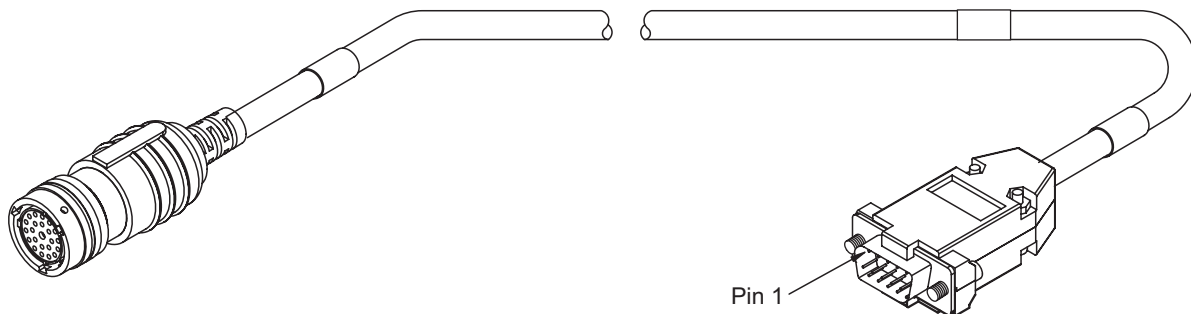
SOLDER SIDE  
Socket



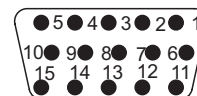
SOLDER SIDE  
Pin



EFCS



SOLDER SIDE  
Socket  
To Motor MG/NT/MH



SOLDER SIDE  
Pin  
To Epsilon EP



## $\mu$ s

Microsecond, which is 0.000001 seconds.

## A

Ampere. The unit of electrical current.

## Amplifier

Servo Drive.

## ARMS

Ampere (RMS).Root Mean Square.

## AWG

American Wire Gauge.

## Baud Rate

The number of binary bits transmitted per second on a serial communications link such as RS-232. (1 character is usually 10 bits.)

## Check Box

In a dialog box, a check box is a small box that the user can turn “On” or “Off” with the mouse. When “On” it displays an X in a square; when “Off” the square is blank. Unlike option buttons, check boxes do not affect each other; any check box can be “On” or “Off” independently of all the others.

## Configuration

The user-created application. It can be saved as a disk file or downloaded to configure the FM-3. It includes all the user-defined setup, assignments and programs.

## CRC

Cyclical Redundancy Check.

## Dialog Box

A dialog box is a window that appears in order to collect information from the user. When the user has filled in the necessary information, the dialog box disappears.

## DIN Rail

Deutsche Industrie Norm Rail

## DLL

In Microsoft Window, a Dynamic Link Library contains a library of machine-language procedures that can be linked to programs as needed at run time.

## Downloading

The transfer of a complete set of parameters from an FM to a drive.

## Drive

Servo drive or amplifier.

## EEPROM

An EEPROM chip is an Electrically Erasable Programmable Read-Only Memory; that is, its contents can be both recorded and erased by electrical signals, but they do not go blank when power is removed.

## EMC

Electromagnetic Compatibility

## EMI - Electro-Magnetic Interference

EMI is noise which, when coupled into sensitive electronic circuits, may cause problems.

## Firmware

The term firmware refers to software (i.e., computer programs) that are stored in some fixed form, such as read-only memory (ROM).

## Flash

Another type of EEPROM.

## Flash File

In the FM-3, this file loads the firmware into the drive and function module. Flash files can field upgrade the firmware.

## FM

Function Module - device which is attached to the front of the drive to provide additional functionality.

## Home Routine

The home provides motion in applications in which the axis must precisely align with some part of a machine.

## Hysteresis

For a system with an analog input, the output tends to maintain its current value until the input level changes past the point that set the current output value. The difference in response of a system to an increasing input signal versus a decreasing input signal.

## I/O

Input/Output. The reception and transmission of information between control devices. In modern control systems, I/O has two distinct forms: switches, relays, etc., which are in either an on or off state, or analog signals that are continuous in nature generally depicting values for speed, temperature, flow, etc.

## Index

An index is a complete motion sequence (defined motion profile) that moves the motor a specific incremental distance or to an absolute position.

## Inertia

The property of an object to resist changes in rotary velocity unless acted upon by an outside force. Higher inertia objects require larger torque to accelerate and decelerate. Inertia is dependent upon the mass and shape of the object.

## Input Function

A function (i.e., Stop, Preset) that may be attached to an input line.

## Input Line

The terminals of a device or circuit to which energy is applied.

## Least Significant Bit

The bit in a binary number that is the least important or having the least weight.

## LED

Light Emitting Diode.

## List Box

In a dialog box, a list box is an area in which the user can choose among a list of items, such as files, directories, printers or the like.

**mA**

Milliamp, which is 1/1000th of an Ampere.

**MB**

Mega-byte.

**MODBUS®**

Communication Protocol by Gould, Inc. for industrial communications systems comprised of programmable controller interface units, protocol software and modems. The MDS drive module follows the Modbus specification outlined in the Modicon Modbus Protocol Reference Manual, PI-MBNS-300 Revision G, November 1994.

**Module**

Function Module

**Most Significant Bit**

The bit in a binary number that is the most important or that has the most weight.

**ms**

Millisecond.

**NVM**

Non-Volatile Memory. NVM stores specifically defined variables as the variables dynamically change. It is used to store changes through a power loss.

**NTC**

Negative Temperature Resistor

**Option Button**

Also known as the Radio Button. Round button used to select one of a group of mutually exclusive options.

**Opto-isolated**

A method of sending a signal from one piece of equipment to another without the usual requirement of common ground potentials. The signal is transmitted optically with a light source (usually a Light Emitting Diode) and a light sensor (usually a photosensitive transistor). These optical components provide electrical isolation.

**Output Function**

A function (i.e., Drive OK, Fault) that may be assigned to an output line.

**Output Line**

The actual transistor or relay controlled output signal.

**Parameters**

User read only or read/write parameters that indicate and control the drive operation. These variables generally hold numerical data defined in the Setup Views.

**PE**

Protective Earth.

**PID**

Proportional-Integral-Derivative. An acronym that describes the compensation structure that can be used in many closed-loop systems.

**PLC**

Programmable Logic Controller. Also known as a programmable controller, these devices are used for machine control and sequencing.

## PowerTools Pro

Windows®-based software to interface with the Epsilon Classic and EP drives, MDS system, and FM-2/3/4 Function Modules.

## Radio Button

See Option Button.

## RAM

RAM is an acronym for Random-Access Memory, which is a memory device whereby any location in memory can be found, on average, as quickly as any other location.

## RMS

Root Mean Squared. For an intermittent duty cycle application, the RMS is equal to the value of steady state current which would produce the equivalent heating over a long period of time.

## ROM

ROM is an acronym for Read-Only Memory. A ROM contains computer instructions that do not need to be changed, such as permanent parts of the operating system.

## RPM

Revolutions Per Minute.

## Serial Port

A digital data communications port configured with a minimum number of signal lines. This is achieved by passing binary information signals as a time series of 1's and 0's on a single line.

## Travel Limit

The distance that is limited by either a travel limit switch or the software.

## Torque

The moment of force, a measure of its tendency to produce torsion and rotation about an axis.

## Uploading

The transfer of a complete set of parameters from a drive to an FM.

## Vac

Volts, Alternating Current.

## Variable

A labeled value that encompasses numeric boolean, input function, and output functions.

## Vdc

Volts, Direct Current.

## Velocity

The rate of change in position in a given direction during a certain time interval.

## Windows, Microsoft

Microsoft Windows is an operating system that provides a graphical user interface, extended memory and multi-tasking. The screen is divided into windows and the user uses a mouse to start programs and make menu choices.

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